FALL
1992

AIR FORCE JOURNAL of LOGISTICS

A Unique Challenge for the Air Force: Mount Pinatubo

BEST AVAILABLE COPY

COVER:
Mt Pinatubo erupting not far from the Clark AB flight line in the Philippines—that same day our troops evacuated the nearby area.

AFRP 400-1

AIR FORCE JOURNAL of LOGISTICS

VOL XVI NO 4

FALL 1992

CONTENTS

Purpose The *Air Force Journal of Logistics* provides an open forum for the presentation of issues, ideas, research, and information of concern to logisticians who plan, acquire, maintain, supply, transport, and provide supporting engineering and services for military aerospace forces. It is a non-directive, quarterly periodical published under AFR 5-7. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Agency, or the organization where the author works.

Distribution Distribution within the Air Force is F. Customers should establish requirements through the PDO system, using AF Form 764, on the basis of 1 copy for every 5 logistics officers, top three NCOs, and professional level civilians assigned. If unable to use the PDO system, contact the editor. *AFJL* is also for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Back issues are stocked at AFLMA/JL.

Manuscripts Manuscripts are welcome from any source desiring to deepen or broaden the knowledge and understanding of Air Force logistics professionals. They should be typed (double-spaced) and be between 1500-3500 words. Figures, graphics, and tables (separate pages) should be numbered consecutively within text. Author may send a diskette (ASCII file) along with the hard copy of the article (Address: AFLMA/JL, Maxwell AFB, Gunter Annex AL 36114; DSN 596-4087, Commercial (205) 416-4087). Articles may also be electronically submitted via DDN. Call for specific instructions.

Refereeing *AFJL* is a refereed journal. Manuscripts are subject to expert and peer review, internally and externally, to ensure technical competence, correct reflection of stated policy, and proper regard for security.

Logistics Management: White-Collar Cloak - Black-Magic Artistry

Kenneth M. Gladstone

This paper explores the fundamental weaknesses in logistics management as a professional discipline and the inability for logistics and its many practitioners to achieve the proper recognition that comes only with the accomplishment of an accredited and nationally accepted standing.

Introduction

Although logisticians may employ a wide range of modern engineering, scientific, and business management practices and procedures in their day-to-day activities, there is as yet no career path baseline that clearly establishes one as a logistician—legitimized and accepted by society at large as an accredited profession. In contrast, engineers, scientists, and business administrators, all feedstock professional backgrounds for logistics managers, have well-established, fully accredited academic programs leading to degree qualification and certification as recognized professionals.

What makes professional logisticians? Although contributing to their background, it is not simply the fact that they are former mechanical engineers, research chemists, macroeconomists, political scientists, or simply accomplished inventory clerks or purchasing agents. Nor is it that they have worked for many years in the same supply-related specialty area. And finally, for clearly the vast majority, if not nearly all, it is not the result of having passed a comprehensive examination certifying their skill level and ability to perform certain duties and responsibilities. While traditional professionals are supported by a rigid hierarchy of academic training, residency, and professional certification leading to practice as engineers, architects, scientists, doctors, lawyers, accountants, and even plumbers, electricians, and master mechanics, no such program protocol, formal developmental structure, or career path exists to become a professional logistician.

To better appreciate the difficulties in treating this subject, one might ask such questions as:

(1) Is an accomplished and experienced procurement specialist a logistician?

(2) Is a traffic management specialist a logistician?

(3) Is a first-line supervisor who has been cross trained in inventory management and cataloguing a logistician?

(4) Does simply working in the field of logistics make one a logistician?

Background

Beginning with its definition, logistics has its problems. Among the most simplistic attempts to capture the essence of the term, logistics has been described as the procurement, distribution, maintenance, and replacement of materiel and personnel. With this concept in mind, some lexicologists have added the phrase "the science of . . ." to the list of functional components comprising the field of logistics. Others have provided additional descriptors including acquisition and disposal to further expand the range of management skills one must master to become a logistician. The point is that the term may take on several different meanings and encompass either an expanding vocabulary of modifiers or a diminishing number of functional components. This depends on the level of sophistication of incorporation of variables by the originator of the word and, equally important, the perception and degree of understanding of the audience in using the word.

Logistics and its practitioners, logisticians, have been around for a very long time. While logistics as a science is arguably believed to have emerged on the battlefield during World War I and as a regular military term during World War II, in point of fact the concept is much older than the twentieth century. Today, the word is linked almost exclusively to military operations and used in the context of military supply management.

In an important sense, history supports this view. For example, even during Greek and Roman times, the massive movement of armies involved a very detailed and sophisticated understanding of logistics. The successes and failures of the Moors and the Crusaders during the early Middle Ages rested in part on how well each society understood and employed sound logistics practices. Napoleon first exploited and then later was victimized by his own conduct of logistics. In an important sense, the disparity between the availability and nonavailability of supplies among the Union and Confederate armies in the American Civil War was a matter of logistics. The unparalleled movement of materiel and personnel to Europe in World War I, and to both the European and Pacific theaters of operation during World War II, has institutionalized the term and made it part of today's vocabulary.

But, it is important to appreciate that logistics, while generally associated with military operations, is not exclusively a military invention. History is replete with examples of its application in a wide variety of settings. The construction of the Great Wall of China and the building of the pyramids involved the skill of logisticians in ways that rival the modern day construction of the Aswan Dam and the current linking of Great Britain with the continent of Europe via the "Chunnel" under the English Channel. So, too, is logistics employed every time the Red Cross responds to disaster relief (earthquakes, flooding, volcanic eruptions, hurricanes, etc.). The commercial airline industry engages in a very sophisticated and fully integrated form of logistics in the movement of people by plane relative to the scheduling and rotation of the aircraft, maintenance and repair of the aircraft, movement of luggage and cargo, feeding of passengers, integration of ground transportation, employment of computer operations, consumption of aviation fuel, and dozens of other variables that contribute to the need for a timely, accurate, and fully reliable transportation industry.

Logistics Today

Despite the recognized need for logisticians and the practice of logistics since man's early beginnings for both military and

nonmilitary purposes, today's logistics managers encompass a wide range of both highly trained and relatively untrained participants, academically and nonacademically qualified program managers, and field experienced and non-field experienced staff specialists. The varying skill bases and textbook knowledge of these individuals blend instinct and experience with differing levels of formal schooling and qualification in the absence of any nationally recognized or sanctioned standard of acceptance and suitability.

Logisticians, by their very nature, are an ill-defined breed composed of laborers, craftsmen, clerks, and technicians, as well as engineers, philosophers, statesmen, business managers, and a host of other individuals in trade specialties and academic disciplines too numerous to list.

The conventional definition of a profession connotes a body of qualified persons within a specific occupation or field. Logisticians, by their very nature, are an ill-defined breed composed of laborers, craftsmen, clerks, and technicians, as well as engineers, philosophers, statesmen, business managers, and a host of other individuals in trade specialties and academic disciplines too numerous to list. Such a varied assortment of skills and backgrounds does not lend itself readily to the concept of a specific occupation or field as the starting place for professional association.

Whereas the American Medical Association is comprised of doctors and the American Bar Association is composed of lawyers, logistics societies (and unfortunately there are many) cannot identify a single job specialty or career field as the basis for affiliation and membership. Moreover, the many different logistics societies—some openly espousing to be professional societies, others de-emphasizing the term—can offer no single standard to ascribe legitimacy to the use of the word "professional."

The conventional professional societies are supported by a rigid hierarchy of academic training, residency, and professional certification requirements leading to licensing and practicing as engineers, architects, scientists, doctors, lawyers, accountants, and even skilled craftsmen such as electricians, plumbers, and master mechanics.

However, no such parallel exists to become a logistician. To begin with, there is no formal schooling program specifically aimed at training to be a logistician. Instead, aspirants with schooling in virtually any academic discipline may use the existence of such schooling to enter the field of logistics. And still others, with little or no formal schooling, are also included in its ranks, particularly if they have distinguished themselves through successful field experience.

Even those institutions with established logistics intern programs may accept engineers and scientists (e.g., an individual with an undergraduate degree in zoology) as candidates for logistics training. And, after acceptance into an intern program, candidates may experience much or very little in the way of logistics training before being designated logisticians. Presently, there are no standardized schooling requirements, core course requirements, or degree requirements to become a logistician. There is no rigidly defined residency requirement, nor is there a universally accepted written and oral examination and certification process.

Companies and organizations may or may not have a director of logistics within their organizational structure. And where such a title exists, the incumbent may be a former warehouse operations employee who has risen to corporate executive status without the benefit of formal education or training. Or the individual so titled may be a white-collar professional from primarily an engineering or business/marketing related background. In the absence of a logistics director, the director of operations or vice president for manufacturing may in fact serve as the logistics manager, having responsibilities for procurement, stock control, inventory, transportation, or warehousing under his/her departmental control.

Even the military has no single entrance and developmental program to train and employ logisticians. Officer candidates from every conceivable background attend different service schools with differing course compositions and curriculum standards for training in such specialties as quartermasters, transportation officers, finance officers, supply officers, and supply operation officers. At the same time, all services provide for the assignment of line officers in staff officer positions as logistics officers and directors of logistics with little or no formal training in the field.

In the Army, infantry, artillery, and other combat arms officers may pursue secondary careers in logistics and logistics management. Senior Air Force pilots no longer in flying status are routinely assigned to positions in personnel administration and logistics. Naval officers enjoy a more clearly defined career path as Supply Corps Officers; but they, too, may share their profession with line officers who are assigned either primary or collateral duties as "Supply Officers" in billets where there is either no provision for, or the nonavailability of, a designated Supply Corps Officer.

Emerging Trends and Strategies

Competing amidst the complexities of today's technological society, industry has máde important strides to single out and elevate the status of logistics and logistics management to further corporate goals and objectives. Indicative of this trend is the emergence of a new hybrid term, "logistics engineer." This term is generally meant to refer to individuals with academic training in an engineering field who are assigned to one or more aspects of logistics support, lending their experience and background to such activities as reverse engineering, material substitution, item identification, cataloguing, technical data and specification writing, engineering drawing review and verification, computer systems hardware and software design, equipment and system testing, facility design and management, packing and packaging, training systems management (including actual equipment, special training devices, simulators, and other training aids), and provisioning (failure rate analysis leading to spare and repair parts allowance determinations).

Oftentimes, engineers, migrating to logistics engineers, become de facto logisticians. Many may become senior company officials in positions comparable to director of logistics or head of the Logistics Support Group. Though not yet standard throughout the corporate world, the emergence of the logistics engineer does signal a trend towards supplanting the logistics management specialist (typically a nonengineering supply specialist) with a more modern logistician possessing a strong, academically qualified engineering background.

Within the federal government, the Department of Defense has recently developed management guidelines embracing special legislation to create a new professional acquisition work force. This work force will include baseline academic entry requirements, internship training, time-in-grade field experience, additional government schooling requirements, and

mandatory time in job placement working agreements for certain positions as principal features of this program. Senior logistics management positions are to be designated as critical and can only be filled by acquisition corps qualified individuals. Introduction and implementation of this new acquisition corps concept represent a revolutionary step forward in the treatment of logistics as a professional career field for government workers.

A number of colleges and universities have begun to introduce courses in logistics management and offer certificate programs in logistics management in general or in one or more of the many sub-specialties and elements contained therein. So, too, various engineering and logistics societies offer a society sponsored certification program which may convey some degree of professional standing and qualification beyond the boundaries of the particular organization involved.

Together, these examples are important first steps in the process of preparing artisans and craftsmen, engineers and scientists, and business managers and personnel administrators, representing a wide range of different backgrounds and levels of training and ability, to become subject area professionals possessing the requisite training, field experience, and community sanction (board certification) expected of mainstream professional practitioners.

The Challenge

In order for logisticians to enjoy the full status of truly designated professionals, there are still a number of key issues that must be addressed:

(1) *A Definition of Terms.* In order to talk meaningfully about problems and reforms, one must first have a concrete grasp of the meaning of the terms "logistics" and "logistician."

In its present usage, the field of logistics represents an indeterminate number of variously prescribed subject area functional components whose makeup and order of precedence are themselves subject to further interpretation or definitional ambiguity (materiel vs material, acquisition vs procurement).

Similarly, the term "logistician" conveys different meanings and imparts varying levels of professionalism among different audiences. For example, are fuels management specialists who work solely in the petroleum industry, by definition, logisticians? Are inventory clerks, stocking clerks, and other trade specialists working in the supply field also logisticians? Is the director of an organizational component entitled "Logistics" a logistician if the individual comes to that position with no previous experience or training in the field? To better illustrate the point, a lawyer may be a municipal court judge, but not all municipal court judges are board-certified lawyers.

Further compounding the problem of definitions is the use of hybrid constructions like logistics engineer. In some cases, such individuals most probably have no such engineering degree and may not even possess any engineering degree, but are working in the field of logistics (not as yet clearly defined). Further, they may have little or no experience in procurement, distribution, or any other one or more of the functional components of the term.

Action. Professional societies or trade associations must take the lead to establish a baseline definitional construct for the use of such words as logistics and logistician and such specialized terms as logistics engineer. Once established, the use of these new definitions must be widely circulated among other professional societies, trade associations, academia, and government, and distributed within the publishing world to ensure a common base for subject matter discussion.

(2) *Hierarchy of Professional Qualification.* Almost anyone and everyone can call themselves a logistician. Just as a housewife may be called a domestic engineer, the spousal acts of shopping, cooking, transporting children to and fro, cleaning house, washing clothes, balancing the family checkbook, and paying bills could be viewed as a form of domestic logistics.

Supply specialists generally call themselves logisticians. Financial specialists and budget analysts may call themselves logisticians. Engineers working in maintenance, material substitution, reverse engineering, and value engineering also call themselves logisticians. Newly hired, entry-level, degree-qualified employees working in the supply field are called logisticians. And career veterans, many non-degree qualified, but having many years of field experience in supply-related matters, are also called logisticians.

Action. Professional societies or trade associations must take the lead to define requirements leading to the proper use of the term "logistician." Moreover, in the process of actually defining the specific requirements, they must examine and specify:

- Ranges and depths of general and specific training to include trade school, certificate program, correspondence, and undergraduate and graduate course requirements.
- Overall non-degree, undergraduate, and graduate degree requirements.
- Entry-level, advanced-level, and management-level experience requirements.
- Protocol for board certification by a national organization, state licensing commission, or combination thereof, encompassing both an oral and written standardized examination process.
- Additional and periodic refresher training requirements.
- Need for additional specialty and sub-specialty certification, and/or recertification requirements.
- Rigidly defined core course requirements and formally sanctioned professional development programs for both engineering and nonengineering oriented future "logisticians" that would consider subject matter mastery in courses related to business management; the fundamentals of economics, computer science, and statistical mathematics; exposure to engineering design and mechanics; and the fundamentals of environmental protection, including hazardous material management and hazardous waste disposal.
- Continuation and expansion of government and industry symposia, trade association fairs, and conventions with particular emphasis on forums, workshops, lecture series, and committees and working groups to foster the exchange of information and ideas.

(3) *A Marketing and Advertising Strategy.* It is not enough for professional societies or trade associations working alone or in partnership with other organizations to develop a rational construct of the definition and organizational framework for the study and practice of logistics. Once outlined and defined, the overall program and supporting processes must be aggressively marketed and advertised and, where appropriate, lobbied to ensure the construct takes root and becomes both routinized and institutionalized.

Existing competing, overlapping, and nonstandardized specialty courses, certificate programs, and other non-degree programs must be systematically examined and then modified, eliminated, or otherwise integrated within the body of prescribed entry-level, advanced-level, and specialty training planned within the new professional framework. Business and trade schools, colleges and universities, and government schooling organizations must be encouraged and possibly, within

reasonable limits, coerced into modifying, adopting, and incorporating subject matter changes into their existing programs to reflect the newly emergent program definition and component requirements identified by the logistics community.

Action. Professional societies or trade associations must take the lead to represent the logistics community and pursue an aggressive and proactive promotional campaign strategy complete with a registered trademark (logo, emblem, or seal) and ensure that all sanctioned and/or endorsed publications, training material, textbooks, and other promotional materials incorporate the logistics community's trademark. And, further, the societies/associations must actively canvass the training community (both in the private and public sectors) to initiate and sponsor logistics training courses endorsed, prepared, or even taught by the societies.

(4) *Professional Review and Self-Policing Mechanisms.* Mainstream professional standing and recognition for logisticians will not be complete without considering the need for continuous training, program management, and qualification standards review and revaluation. Established "professionals," notably doctors, lawyers, accountants, architects, dentists, teachers, and even insurance underwriters, are supported by separate, distinct, and nationally recognized professional societies that actively promote their specialty area interests, dictate additional and refresher training requirements, and in a very real sense govern the conduct of their separate constituencies. Various committees and review boards within these prominent and established professional societies and associations are responsible for their own program reviews and evaluations and, especially, for the varying degrees of licensing standards, qualifications, and even license revocations within their acknowledged areas of jurisdiction.

Action. To achieve full professional standing, the logistics community must first unify its currently diverse makeup. There needs to be a nationally recognized spokesman to represent the interests of all concerned, either through mergers and consolidation among the several leading logistics organizations or through agreement to designate or defer to one group as the principal spokesman for the profession.

Then, acting through the designated advocacy, the community must embrace the concept of self-review and self-policing by establishing the infrastructure (special committees and boards) to conduct its own nationwide program reviews and effect or otherwise influence certification and licensing standards, qualification, and revocation through aggressive lobbying for licensing legislation and establishing uniform testing and licensing practices in all states.

The already established, fully professional societies have distinguished themselves through legitimization of nationally recognized organizational structures with regional, state, and local chapters. And they have founded a uniform examination and licensing process administered with the assistance of the organizations themselves or in conjunction with established state boards and licensing commissions that are actively supported by these societies.

Professionalism in the classic sense of the word connotes great skill or experience in a particular field or activity. If logisticians are to become truly professional, they must adopt the mantle of legitimacy enjoyed by the already established professional organizations. They must clearly identify the universe of background skills and knowledge required to enter the field. They must institutionalize the requirement for formal training within defined areas of the arts and sciences to produce capable and technically qualified practitioners. And, they must demonstrate their competence through a combination of actual experience, formal examination and certification, further advanced specialty training, and periodic refresher training that is sanctioned by a nationally recognized organization acting alone or in conjunction with duly established governmental boards and commissions.

Towards Professionalism—The Society of Logistics Engineers

The Society of Logistics Engineers is already well positioned to take the lead to move the logistics community to the ranks of true professionalism. Having in place an examination protocol for members of the society, there is the nucleus of a testing and licensing certification process that can be expanded and "legitimized" through legislation leading to standardization and institutionalization among the states similar to the examination and licensing for lawyers, doctors, accountants, etc.

Sponsoring and providing advisory policy guidelines, definitional constructs, and modeling algorithms, and publishing noteworthy journal articles, are the hallmarks of nationally recognized professional societies that serve as the spokesmen for their industries.

In addition, the society has been a leading advocate for improvement in the application of systems engineering, computer modeling, and the enhancement of life-cycle costing techniques as necessary tools for the successful application of logistics practices and procedures in both industry and government. Sponsoring and providing advisory policy guidelines, definitional constructs, and modeling algorithms, and publishing noteworthy journal articles, are the hallmarks of nationally recognized professional societies that serve as the spokesmen for their industries. Using the talent and existing committee structure of the organization, the Society of Logistics Engineers should further capitalize on this resource capability to actively promote, for example, a standard model or protocol for life-cycle costing for use by industry and government alike.

And lastly, the society presently sponsors a rigorous and well-rounded teaching and educational program. This membership and public service activity is also an important building block in the establishment and maintenance of a nationally recognized professional organization of prominence and respect. Building on this educational program affords an excellent opportunity to further strengthen the society's relationship and interaction with the trade school, university, and government educational communities, and actively participate in the development of standards and joint accreditation and qualification for course work, program certification, and the conference of baccalaureate and advanced degrees in the fields of logistics and logistics engineering.

The original version of this article appeared in the 27th Annual International Logistics Conference Proceedings of the Society of Logistics Engineers (1992).

Kenneth Gladstone, who is a former Naval Officer and presently a Supply Corps Captain in the Naval Reserve, is Hazards Waste Project Manager, Environmental Engineering Group, Naval Sea Systems Command, Washington DC.

Redefining Before Refining: The USAF Reparable Item Pipeline

Captain Bradley M. Kettner, M.S., USAFR
Captain William M. Wheatley, M.S., USA
Major David K. Peterson, Ph.D., USAF

During the 1980s, successful commercial logistics operations evolved towards shorter lead-times allowing for leaner inventories. Increased competitiveness, faster inventory turnovers, and reduced inventory investment were the payoffs to leading-edge firms which adopted this new philosophy. The US Air Force, however, experienced a tremendous growth in spare parts inventory investment during this same time period due to a commitment towards improved military readiness. In fact, USAF inventories reached into the millions of assets worth literally billions of dollars. Now that more stringent fiscal constraints have been imposed, USAF inventory managers are striving to maintain high readiness levels while faced with ever leaner inventory investment funding. As both examples demonstrate, inventory managers must respond to fundamental, strategic organizational challenges by improving their logistics pipeline's performance. This article outlines a systematic approach for analyzing logistics pipelines and charting potential improvements. Further, it provides an example of how this approach was applied to a portion of the Air Force's logistics pipeline.

General Concept: What Is a Pipeline?

One of the prerequisites to improving a logistics pipeline is reaching a common understanding of what it is. Unfortunately, there are many managerial perceptions, each of them slightly different, of what constitutes a pipeline. The American Production and Inventory Control Society defines pipeline stock as:

> Inventory to fill the transportation network and the distribution system including the flow through intermediate stocking points. The flow time through the pipeline has a major effect on the amount of inventory required in the pipeline. (18:22)

Another definition places additional emphasis upon asset demand requirements in a manufacturing or maintenance environment:

> Pipeline . . . inventories include goods in transit . . . between levels of a multi-echelon distribution system or between adjacent work stations in an assembly line. The pipeline inventory of an item between two adjacent locations is proportional to the usage rate of the item and to the transit time between the locations. (14:60)

For any particular organization, either of these definitions may be equally valid. The important point is that a logistics pipeline must be defined with respect to its organizational context. The challenge, however, is that this is a moving target.

What Happens to These Pipelines?

Obviously, to implement and operate a complex logistics infrastructure, someone, somewhere, at some time, had to know exactly what the pipeline was (or at least specific components of it). What happens to these pipelines as they operate over time? They change! As Wagner states:

> The organization of most logistics operations in an enterprise is based on historical evolution; changes have taken place, if at all, typically at times of crisis. (17:103)

In fact, some authors go so far as to claim that "the majority of [distribution] channels are not designed, but evolve over time." (15:92)

As Wagner notes, pipelines tend to be changed during times of crisis. Furthermore, they change within a manager's parochial interests and control; in other words, there exists an institutional tendency to optimize locally:

> . . . any pipeline has a number of interfacing control systems, and a number of organizations involved in attempting to control it . . . each of these organizations may be seeking to optimize the performance of its own element. And their best intentions may well be detrimental to the effectiveness of the pipeline as a whole. (10:16-17)

What Does All This Mean?

Although different in their specific designs, all logistics pipelines share some common themes: quantity, flow rate, volume, and direction. As these complex systems operate over time, they evolve. To the degree that this evolution suboptimizes the entire logistics pipeline system, more inventory is required to maintain a satisfactory level of customer service (however it may be measured). This increased level of inventory is the result of logical disconnects within the organization's logistics subsystems.

Therefore, managers must carefully reexamine their organizations to revitalize logistics pipelines and accommodate leaner inventories. Old conceptualizations of the pipeline may no longer be valid and must be updated. Although difficult, these efforts can yield significant payoffs:

> Yet almost always large improvements can be made as a result of a comprehensive look at the logistics needs of the organization. More often than not, much of the improvement devolves from realignment of responsibilities along with appropriate management review and control, rather than from revision of isolated decision making processes. (17:103)

During the last two decades, a significant portion of inventory management research was devoted towards doing exactly what Wagner suggested—reexamining the organization's logistical needs. Researchers and managers rediscovered that the inventory system's operational philosophy is as important as mathematically optimizing its inventory stockage policies.

Revising Philosophies Requires a Systems Perspective

Traditionally, inventory managers have tried to maintain a sufficient level of inventory to achieve some desired customer

service level. Often, service was measured in terms of issue effectiveness. This philosophy drove organizations to high inventory investment levels; for example, "A full pipeline is a good pipeline." In the late 1970s and early 1980s, however, other inventory management philosophies emerged which took a broader view of the organization.

The JIT Revolution

In its broadest sense, just-in-time (JIT) is an inventory management philosophy which "means to produce the necessary units in the necessary quantities at the necessary time." (8:37) Intended for dependent demand environments, such as a manufacturing facility, this philosophy encourages low levels of inventory within a system. This, in turn, leads to lower levels of inventory investment and faster inventory turnover. In other words, the entire organization is more productive (and competitive) because its inventory investment is working harder.

To sustain market share, given JIT's reduced inventory levels, companies must become more efficient from an operational standpoint. Due to low inventory levels, buffers are lost between workstations. A change in any single process (from delivering raw materials to scheduling units on the final assembly line) ripples throughout the remainder of the system. As inventory levels drop, new operational problems are exposed which require companies to reexamine the very design and structure of their productive processes.

TOC Bottleneck Identification

In the late 1980s, a complementary philosophy of business management gained recognition. Called the Theory of Constraints (TOC), it emphasized that the goal of a firm was to make money. In fact, a firm could increase the amount of its profit only through one or more efforts: (1) increasing throughput, (2) reducing operational expenses, (3) reducing inventory, or (4) any combination of these three.

By identifying the bottleneck within a productive organization, managers could accurately evaluate the effect of their attempts to resolve the bottleneck's cause. The key, under this management philosophy, is correctly identifying and then methodically managing the organization's bottleneck. This is true whether the bottleneck is a process or an organizational policy. The basic methodology consists of determining what to change, what to change to, and how to cause the change. (5:36) To successfully implement TOC bottleneck management requires an intimate knowledge of the productive system.

Systems Knowledge Is Required

Two of the most recent inventory management philosophies to arise, JIT and TOC, both explicitly require a thorough knowledge of an organization's productive processes and policies. Without an adequate understanding of the entire system, improvement efforts are haphazard at best and counterproductive at worst. This lesson is equally applicable to a manufacturing or service part inventory management environment.

The problem is, how do you obtain this knowledge? Essentially, one must develop an approach to thoroughly analyze and improve an organization.

A Systematic Approach for Logistics Pipeline Analysis

If the JIT revolution or the TOC challenge taught us anything, it is that one must be able to accurately describe a system in order to manage it or improve it. If it is an existing system, a system that has evolved, then the logistics manager needs a systematic approach to gain the requisite knowledge. A reasonable tack is to (1) apply a systems perspective, (2) redefine the pipeline's definition to match its current operation, and (3) embark upon logical refinements.

What Is a Systems Perspective?

Schoderbek, et al, provide the initial framework for this analysis. They define a system as:

> . . . a set of *objects* together with *relationships* between the objects and between their *attributes* connected or related to each other and to *their environment* in such a manner as to form an *entity* or *whole*. (12:12)

A systems perspective, then, is essentially viewing any particular problem in a macro, organizational context. (12:7-8)

An Accurate Pipeline Description Is Presupposed

This focus on the overall system is critical. One of the easiest and most accurate mechanisms for doing this is using flow diagrams. As Blanchard notes:

> The translation of system operational and maintenance concepts into specific qualitative and quantitative design requirements commences with the identification of the major functions that the system is to perform followed by the development of functional flow diagrams. Functional flow diagrams are employed as a mechanism for portraying system design requirements in a pictorial manner . . . . (2:118-119)

Flow diagrams are an important first step to help logistics managers visualize the entire pipeline and how their areas of responsibility contribute to it. These diagrams serve as new benchmarks for how the system is actually functioning, not how someone assumes (or remembers) it is operating. Furthermore, they help curtail the local optimization which occurs as managers of systems respond to changes in their operating environment. An added benefit is that flow diagrams aid understanding the linkage between elements in a system. (2:119)

Pipeline Refinements Based on Measured Performance

Given that the logistics pipeline can be accurately described, its performance must be measured. As Ploos Van Amstel notes:

> The division of a pipeline into elements enables responsibilities to be clearly defined while measurement is facilitated. (10:24)

Three key steps to measuring pipeline performance are:

(1) Determine the pipeline norm times.

(2) Measure the actual situation.

(3) Periodically report on the actual situation with respect to the stated norms. (10:20)

Once the performance of pipeline elements is measured, how can the entire logistics pipeline system's performance be improved? Current management philosophies such as JIT or TOC would suggest focusing on reducing the time required to process units through critical operations. This means more than just driving down the average time it takes to process a unit through the operation; its associated variability must also be reduced.

Management Awareness Is the Key

One of the biggest challenges for improving logistics pipelines is getting managers to apply a systems perspective. As managerial understanding of the pipeline increases, and the logical linkages between its subsystems improve, the entire

system will be able to operate more efficiently with less inventory investment.

Whether one wants to label this growth in managerial awareness as the systems approach, Deming cycle, or just good common sense, there are three main steps. (12:281; 11:64-69) First, there must be an acknowledgment that the system as a whole is not performing at a level adequate to satisfy today's organizational needs. Next, the existing system must be documented and modeled—not only the physical flow of assets, but also the information flow. Finally, system performance must be measured and evaluated to identify what changes seem reasonable to improve performance.

USAF Inventory Management Background

During the 1980s, the USAF inventory investment grew, with the majority of it being in reparable spares. The inventory methods of choice for managing reparables in a service parts (independent demand) environment are pipeline models.

The USAF Reparable Item Logistics Pipeline

A reparable asset is an item so designed that it is capable of being repaired after it breaks. Typically, reparables are very expensive, with long procurement lead-times, which makes their repair a cost-effective alternative. Although outnumbered in sheer volume by consumable inventories, reparables represent the majority of inventory investment in the USAF supply system. Typical reparable assets include radios, landing gear, and similar items. By convention, the term "reparable" refers to a class of supply items while the term "repairable" refers to the physical condition of any particular asset. Synonymous terms for reparables are recoverables, rotables, and exchangeables.

Within the USAF, the movement of reparables is commonly conceived of as a pipeline (Figure 1). Consider the case where a radio fails on an aircraft. When a radio fails, it is removed from the aircraft and sent to the base intermediate-level maintenance complex. Here technicians attempt to fix the radio by repairing/replacing its failed components. Meanwhile, base supply issues a fully serviceable, replacement radio to the aircraft maintenance technician for reinstallation on the affected aircraft.

If the local repair is successful, the now serviceable asset is turned in to base supply. If the radio cannot be repaired locally, it is sent to depot-level maintenance. At the depot, failed assets not only are repaired, but are remanufactured. Remanufacturing is an "industrial process in which worn-out products are restored to like-new condition." (18:27) While the repairable asset is in transit, base supply simultaneously requisitions a serviceable replacement from depot supply to maintain its authorized stock levels. The process just described is also commonly referred to as reverse logistics.

The important point about the foregoing discussion is that it is at a very typical level of detail for imbedded USAF logistics/inventory models. (4:281 and 293) Since the 1960s, a great deal of effort has gone into developing and refining inventory models based on pipelines similar to that previously presented. While models of this type are very good for computing stockage requirements, they were never designed (nor intended) for actually being used as the bases for managing and improving/refining current logistics processes. When inappropriately used, these models can easily misdirect a logistician's efforts towards managing by fixed standards, rather than attempting to improve the intrinsic behavior of the process. When this occurs, logisticians fall into the trap of trying to optimize their portion of the pipeline without regard to potential impacts on the overall system. The only way to truly reduce pipeline inventory requirements will be to streamline processes within each major pipeline segment.

US DOD Inventory Dynamics

Traditionally, military logisticians have believed that as long as the pipeline was "full," the mission was being adequately supported. The 1990s, however, promise to be a decade of major reorganization in the military's mission, force structure, and operational philosophies.

Just as private enterprises cut inventory costs in the 1980s, the Department of Defense (DOD) has been developing initiatives (since 1989) aimed at reducing the cost of national defense to the absolute minimum. The aim of these initiatives, referred to as Defense Management Review Decisions (DMRDs), was to reduce DOD expenses by $30 billion over the first five-year period, Fiscal Years 1991 through 1995. (1:6) The logistics pipeline was identified as one of the primary sources of these savings:

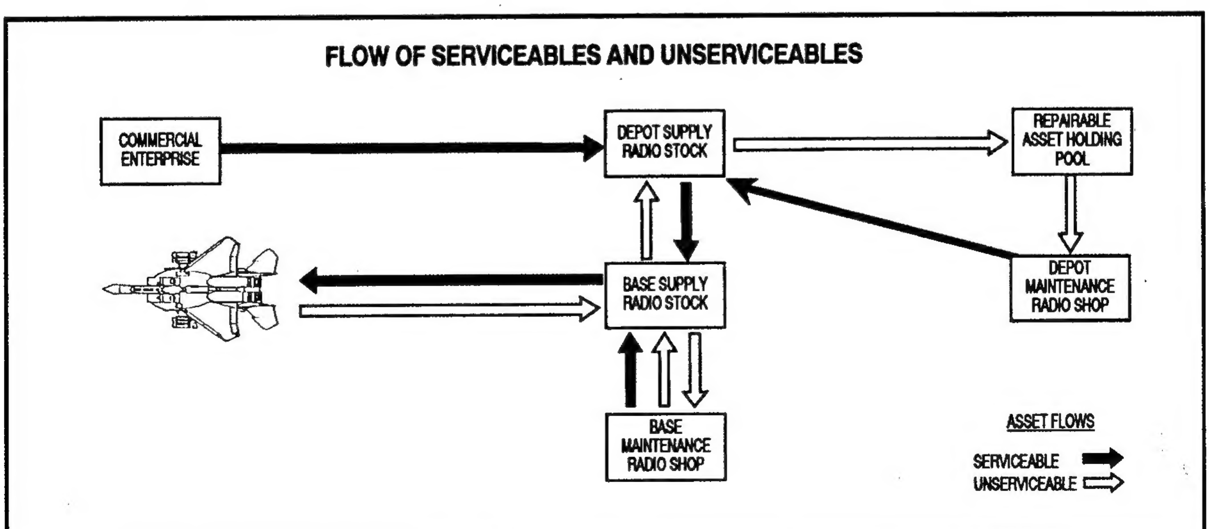


Figure 1. Reparable pipeline.

> The annual cost to run the Department of Defense supply system approaches $27 billion. These costs include, among others, the material costs to procure spare parts, the transportation costs to position the material, and the associated operating costs at the inventory control points and wholesale stock points . . . . With the significant amount of funds and resources devoted to supply support, it is easy to understand why the very first DMR initiative to be issued, DMRD 901, addressed the reduction of these supply system costs. (16:8)

Naturally, these initiatives triggered an intense interest by USAF logistics managers to trim the reparable pipeline. (13:18) Despite this increased interest on the part of logistics managers, the process of reducing the pipeline is no easy task. Logisticians will face numerous problems which require major shifts in inventory management philosophies.

One Example of the Problem

In 1991, Perry published a survey of DOD remanufacturing organizations. A significant finding from his examination was that DOD remanufacturing organizations focused too much on the actual costs of repairing an asset and resource utilization. In contrast, the associated inventory investment, driven by the efficiency of the remanufacturing process, received too little emphasis. (9:42) As Perry noted, this misplaced emphasis was:

> . . . a result of basic scheduling and lot sizing decisions which were made to increase remanufacturing efficiency at the expense of inventory investment, measured lead times in the DOD components surveyed were substantially overstated relative to engineering standards . . . these actual remanufacturing lead times were approximately double (202%) the established standard times. (9:43)

Intermediate Summary

Given today's shrinking military budgets, and the emphasis upon managing the services as business enterprises, there is renewed interest in efficiently reducing inventory investment. To achieve this reduction in inventory investment, the USAF must shorten its logistics pipeline—just as commercial firms shortened their lead-times during the 1980s. Unfortunately, no comprehensive, well-defined description of the USAF reparable item pipeline, or its components, existed. As a result, efforts to reduce the pipeline lead-times were disjointed, being based on studies limited in scope.

Developing a Systematic Approach for Pipeline Improvement

A review of recent efforts to identify and shorten the USAF reparable item pipeline revealed that, as of 1988, there was no clear understanding of the reparable pipeline's entirety. In 1989, a team of Air Force researchers developed a comprehensive conceptual model of the USAF's reparable item logistics pipeline to help in defining just what functions the reparable item pipeline actually encompassed. The model consisted of four major subsystems: (1) acquisition, (2) base-level, (3) depot-level, and (4) disposal. (3:169) Their study is one of the few USAF reparable item studies which applied a systems perspective.

More recently, managerially oriented pipeline studies did not provide an adequate level of detail for pipeline processes. Analysis of these studies revealed that, although many models of the reparable item pipeline exist, most are limited in scope to those portions of the pipeline directly under the sponsoring organization's control. This limitation resulted in entire segments of the reparable item pipeline (and their linkages) receiving little or no management attention.

As mentioned previously, local optimization does not ensure global optimization. Modifying any complex logistics process fundamentally demands a systems perspective. Thus, these very detailed, managerially oriented studies could not ensure that optimizing one segment of the pipeline had not impaired another segment's performance. The remainder of this article develops a systematic approach to improve pipeline performance. An enhanced model of the Air Force's reparable item pipeline is presented for illustration.

Step One - Assume a Systems Perspective

The first step towards improving pipeline performance is to assume a systems perspective. To accomplish this, management must disregard all existing assumptions about the pipeline in question. Goldratt made this point very directly when he stated:

> It is clear that the nature of human beings is such, that as long as we think that we already know, we don't bother to re-think the situation. (5:36)

Many managers believe they are rethinking a situation, when, in reality, they are simply confirming their imbedded assumptions.

Since it can be difficult getting around these imbedded assumptions, an organization may want to consider using a consultant or disinterested third party to review its pipeline processes. Using a third party may be beneficial "not because he knows more or has a broader base of experience, but because he is not attached to the rooted assumptions—the inertia of the organization." (5:89) Only after these assumptions are set aside can the true pipeline's operations be accurately described.

By applying this systems perspective, and using early conceptual models by Captains Bond and Ruth (3), and Major General William Hallin, then DCS, Requirements, HQ AFLC, as baselines, an enhanced model was developed which focuses on the entire depot-level subsystem of the reparable item pipeline (Figure 2). The research examined both the asset flow as well as the information flow. These two distinct types of flows exist in every pipeline, and both must be reviewed. This enhanced model is divided into six major segments: (1) base processing, (2) reparable in-transit, (3) supply-to-maintenance, (4) shop flow, (5) serviceable turn-in, and (6)order and shipping time. It also accommodates programmed depot maintenance (PDM) and new item acquisition.

The enhanced model presented in Figure 2 begins and ends with the user of the serviceable assets. This user could also represent an end-item customer in private industry. The model describes an entire cycle followed by a broken asset as it flows through the repair process.

An asset enters the reparable pipeline when the base-level maintenance shop determines the asset is not repairable this station (NRTS) and must be repaired/remanufactured at a depot-level maintenance facility. This marks the beginning of the base processing segment of the model. The asset moves through the base-level supply function where disposition instructions are determined and the asset is readied for shipment.

Once the asset has been packaged for shipment, it enters the reparable in-transit segment of the model. Forwarded to the transportation function at base level, the asset is final-packed, inspected, and labeled, and the shipment planned and coordinated with the applicable carrier. The mode of shipment can vary depending on the size and/or criticality of the broken asset. Upon arrival at the depot, the asset is delivered directly to the depot supply receiving activity. The asset now enters the supply-to-maintenance segment of the pipeline.

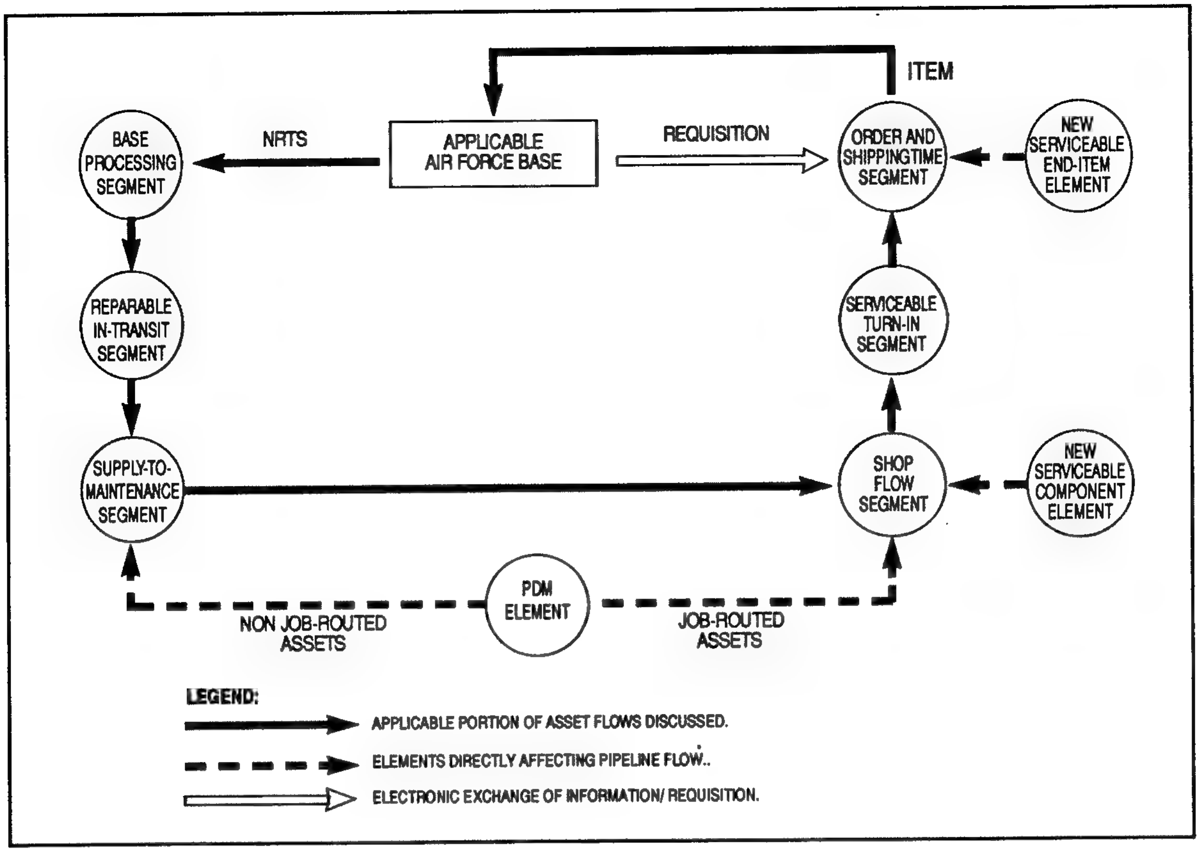


Figure 2. Depot-level reparable pipeline. (7:129)

In this segment of the pipeline, broken assets from either a base or other depot functional elements such as the PDM (aircraft overhaul) activity are in-checked and processed. If the maintenance shop is in immediate need of work, the broken asset is sent to the repair shops through an express handling area. If an immediate requirement does not exist, the broken asset is placed in storage until a work requirement does exist. Once the asset has been delivered to the depot repair shops, the asset enters the shop flow segment of the pipeline.

This segment is the most complex and difficult portion of the pipeline to model. Each reparable asset may have its own unique flow through the repair process depending on which of its components are in need of repair. (A more detailed process flow diagram is presented later describing a generic layout which can be tailored to any specific item's repair flow.) Once the asset has been repaired, it is ready to be returned to supply or depot maintenance.

The serviceable turn-in segment begins when the now serviceable asset is ready to be returned to depot supply and awaits transportation to supply's central receiving function. If a customer requisition exists, the asset is sent to an express packing and crating activity to be prepared for shipment. If no immediate requirement exists, the asset is stored to satisfy future needs.

Requirements are identified through the order and shipping time segment of the reparable pipeline. This segment of the pipeline consists of three elements: order time, processing time, and shipping time. (13:19) Order time begins with the generation of a requisition in the base-level computer system and ends when the depot-level supply computer system receives the requisition. Once the requisition is received by the depot, the shipment processing time starts. This processing time varies depending on the availability of serviceable assets. Shipping time begins when a carrier receives an asset and ends when the asset is delivered to the requesting base. Once the serviceable asset is delivered, the depot-level reparable pipeline has completed its cycle.

The actual pipeline is much more complex than presented here. This discussion was limited to a very general overview of the model. However, every attempt was made to identify the interdependencies that exist between the pipeline segments and other functions such as acquisition and PDM. By applying a systems perspective, this enhanced model clarifies the flow of assets through the depot-level pipeline subsystem. Spanning organizational boundaries, it ties previous loosely related management functions into a more concise, unified whole.

Step Two - Redefine Pipeline Processes

Once a systems perspective is achieved, the second step is to redefine pipeline processes. This can be accomplished by using more detailed flow diagrams. Walton advocates the use of flow diagrams for developing an insight into processes being reviewed:

> Often the first step a team looking for ways to improve a process takes is to draw a flow chart of that process. A process cannot be improved, the reasoning goes, unless everyone understands and agrees on what the process is. The flow chart is an extremely useful way of delineating what is going on. (19:102)

Process flow diagrams were developed for each segment of the enhanced model. The flow diagram shown in Figures 3 and 4 details a generic shop flow at the time of the study.

The detail of this diagram is at the lowest level which accommodates repair processes common to most (although not all) broken assets. These steps include: (1) an induction process, (2) testing to isolate discrepancies, (3) a disassembly and cleaning process, (4) non-destructive inspections, (5) repair

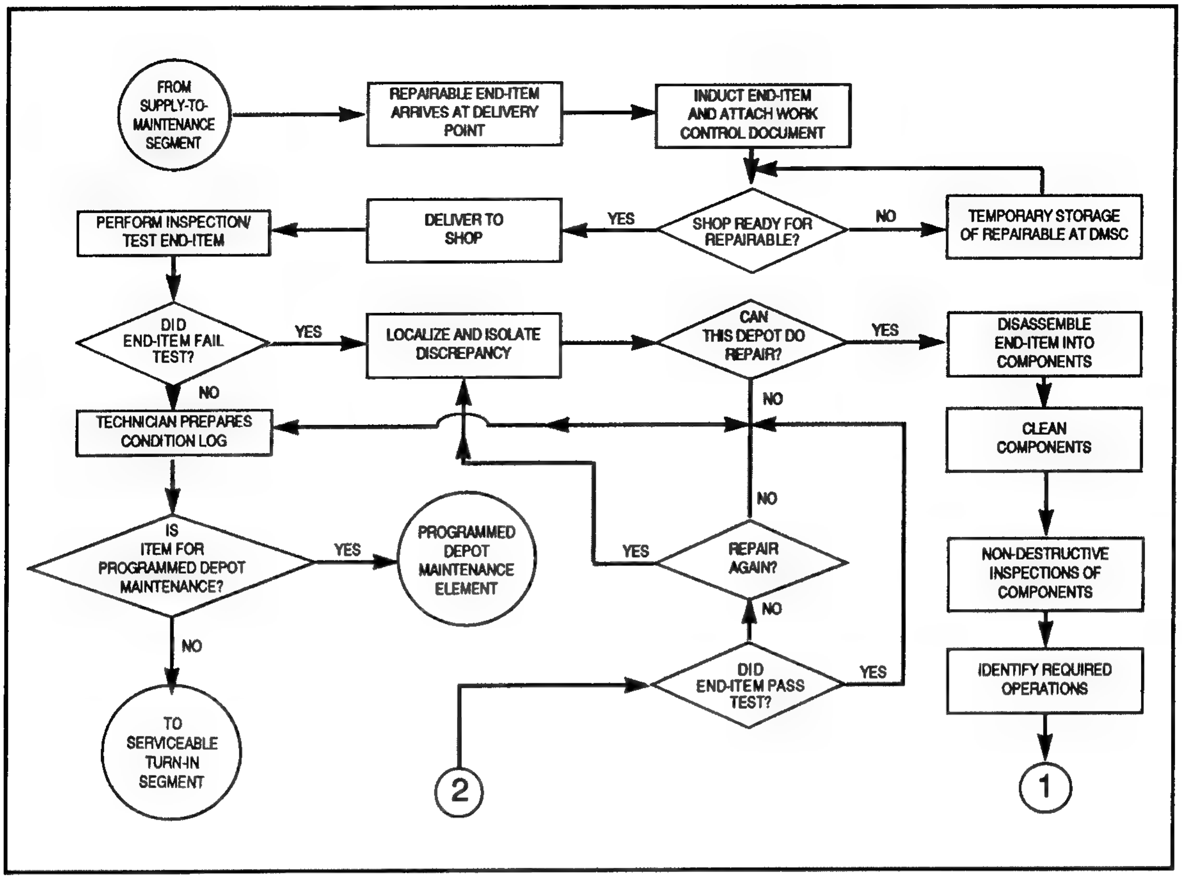


Figure 3. Detailed shop flow (Part 1). (7:140)

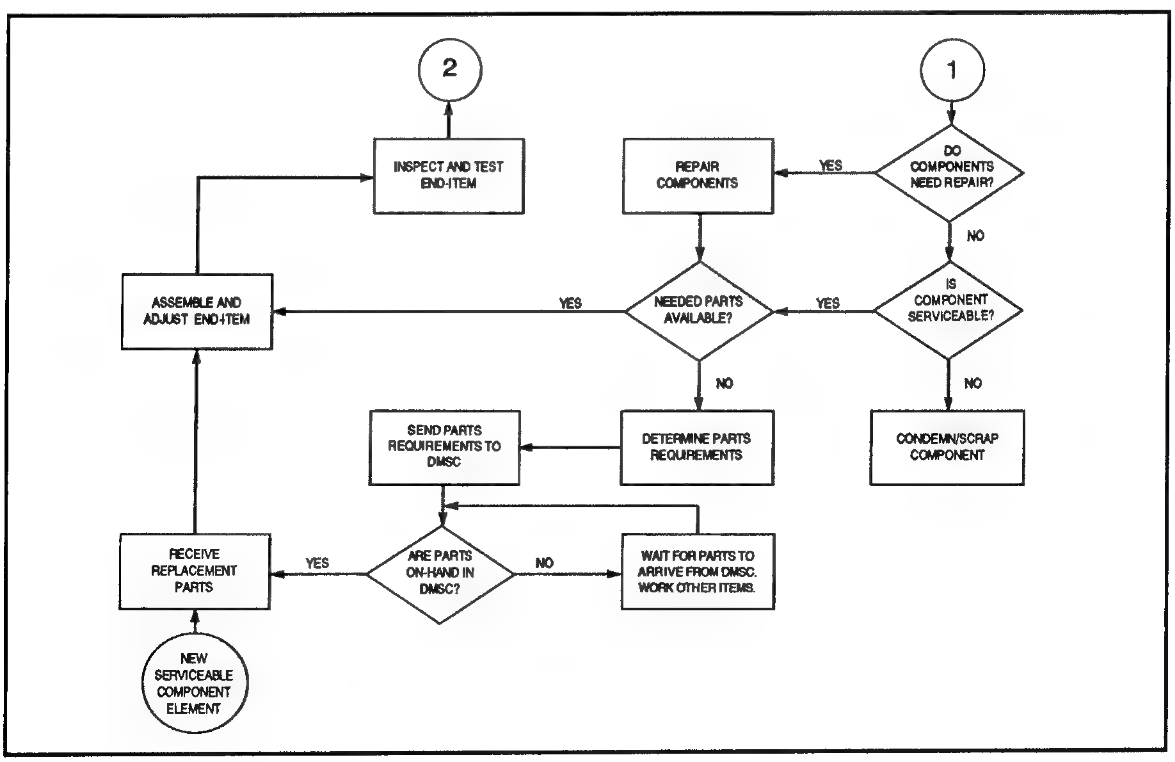


Figure 4. Detailed shop flow (Part 2). (7:141)

processes, (6) reassembly and adjustment, and (7) testing of the reassembled item. (2:36) Since each type of end-item can have unique repair processes, it is not feasible to develop one model which covers all repair possibilities. Flow diagrams can serve as a road map for managers to use when changing processes or conducting more detailed studies. These diagrams serve the same role as a blueprint serves for a contractor who is remodeling a building. The blueprints need to be reviewed prior to making changes and then updated as changes occur. Otherwise, a disaster is waiting to happen, and most likely will.

Step Three - Refine the Process

The third step involves focusing management's efforts on pipeline improvement only after they are completely familiar with its current operation. It is imperative that redefining the existent logistics pipeline precede any attempts at refining it. The detailed flow diagrams facilitate objectively analyzing and ultimately streamlining reparable item pipelines through continuous improvement. For example, are all the activities in this complex process truly necessary? How quickly do assets flow through the pipeline segments? How variable are their flow times?

These questions are ones that all logistics organizations, whether military or commercial, must answer. Managers can use process flow diagrams to help them focus in on problem areas, allowing them to develop "system friendly" fixes. This requires collecting appropriate (not just "convenient") performance data. Not only should the mean time it takes for assets to flow through segments of the pipeline be reduced, but also the variability of their processing times. Eventually, portions of the pipeline can be computer simulated to examine even larger scale structural changes in the pipeline without risking ongoing mission support.

At this point, it is up to senior executives to promote "large scale process improvement" (6:171) and interfunctional cooperation within the organization. Senior managers must encourage a focused, system-wide perspective. Armed with the detailed knowledge of how their processes really work, mid-level managers can begin to logically refine pipeline processes and policies. This step may initially be to just improve information gathering/performance measurement to better reflect the actual pipeline processes. Regardless of the initial results, managers must continue to periodically reexamine the pipeline to ensure that the actual processes are still properly identified and in control. Assuming that nothing has changed is a risky decision that is best avoided in today's competitive world.

Summary

As Perry recently noted, by the year 2000:

> Cost will continue to be a major concern for U.S. corporations in the global economy. However, the specific make-up of costs will shift from emphasis on direct labor to greater concentration on material costs and indirect costs. Material costs will be reduced by successful firms through better product design and standardization, innovative use of transportation, more effective purchasing and materials management, and reduced inventories. (9:6)

The challenge of reducing inventories can best be met through effective pipeline management. By increasing the productivity of an organization's logistics pipelines, a firm is well on its way to meeting customer needs at a minimum overall cost.

The first step in this productivity reevaluation is to assume a systems perspective based on the reality of existing pipelines, not what management thinks the pipeline is. The next step is to redefine the pipeline process using flow charts as guides. Once management fully understands the actual pipeline's operation, they can focus their attention on improving its productivity and performance. Finally, based on their newfound knowledge, managers can refine the process. The key to successful pipeline management is reacquainting management with the reality of the processes they manage. By redefining before refining, managers are assuring that their decisions will serve the best interests of the entire logistics pipeline system.

References

1. Arthur, Vice Admiral Stanley R. "The DMR Challenge," *The Navy Supply Corps Newsletter*, 53 (September/October 1990), pp. 6-7.
2. Blanchard, Benjamin S. *Logistics Engineering and Management* (Second Edition), Englewood Cliffs NJ: Prentice Hall Inc., 1981.
3. Bond, Craig A., and Ruth, Marvin E. *A Conceptual Model of the Air Force Logistics Pipeline*, MS Thesis, AFIT/GLM/LSM/89S-2, School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1989 (AD-A216158).
4. Demmy, W. Steven, and Presutti, Victor J. "Multi-Echelon Inventory Theory in the Air Force Logistics Command," *TIMS Studies in the Management Sciences*, 16, edited by Leroy B. Schwarz, Providence RI: North Holland, 1981.
5. Goldratt, Eliyahu M. *Theory of Constraints*, Croton-on-Hudson NY: North River Press Inc., 1990.
6. Kallock, Roger W. "Reengineering Business Logistics," *Council of Logistics Management Annual Conference Proceedings*, Anaheim CA, 1990, pp. 171-186.
7. Kettner, Bradley M., and Wheatley, William M. *A Conceptual Model and Analysis of the Air Force Depot Supply and Maintenance Pipeline for Reparable Assets*, MS Thesis, AFIT/GLM/LSM/91S-37, School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1991.
8. Monden, Yasuhiro. "Adaptable Kanban System Helps Toyota Maintain Just-In-Time Production," *IE*, 13 (May 1981), pp. 29-45.
9. Perry, James H. "The Impact of Lot Size and Production Scheduling on Inventory Investment in a Remanufacturing Environment," *Production and Inventory Management Journal*, 32 (3rd Quarter 1991), pp. 41-45.
10. Ploos Van Amstel, M. J. "Managing the Pipeline Effectively," *Journal of Business Logistics*, 11 (February 1990), pp. 1-25.
11. Scherkenbach, William W. *Deming's Road to Continual Improvement*, Knoxville TN: SPC Press, 1991.
12. Schoderbek, Charles G., et al. *Management Systems: Conceptual Considerations* (Revised Edition), Dallas TX: Business Publications Inc., 1980.
13. Silver, Bradley. "Reduction of Recoverable Pipeline," *Air Force Journal of Logistics*, Vol XV (Summer 1991), pp. 18-20.
14. Silver, Edward A., and Peterson, Rein. *Decision Systems for Inventory Management and Production Planning* (Second Edition), New York NY: John Wiley and Sons, 1985.
15. Stock, James R., and Lambert, Douglas M. *Strategic Logistics Management* (Second Edition), Homewood IL: Richard D. Irwin Inc., 1987.
16. Stone, Commander Daniel H. "Reduced Supply System Costs," *The Navy Supply Corps Newsletter*, 53 (September/October 1990), pp. 8-10.
17. Wagner, H. M. "The Next Decade of Logistics Research," *Science, Technology, and The Modern Navy*, edited by E. I. Salkovitz, Arlington VA: Office of Naval Research, 1976.
18. Wallace, T. F., and Dougherty, J. R. *Dictionary*, Falls Church VA: APICS, 1987.
19. Walton, Mary. *The Deming Management Method*, New York NY: Perigee Books, 1986.

The original version of this article appeared in the 27th Annual International Logistics Conference Proceedings of the Society of Logistics Engineers (1992).

Captain Kettner (USAFR) works in the Air Force Audit Agency at Wright-Patterson AFB, Ohio. Captain Wheatley is assigned to the Quarter Master Center, Fort Lee, Virginia. Major Peterson is an Associate Professor of Logistics Management at the Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Clark Air Base Versus Mount Pinatubo

Colonel Kenneth B. Faulhaber, USAF

After almost two years on the PACAF staff, I assumed duties as the Director of Supply on Monday, 10 June 1991. Before that first week ended, Mount Pinatubo erupted in the Philippines and literally buried Clark Air Base. What follows is one man's view of how we recovered supply operations at Clark and then evacuated the base. Obviously, it is a MAJCOM and supply perspective; and I am sure there are much more interesting and colorful recollections from the "Ash Warriors" who were actually at Clark.

Before that first week had ended, we knew only two things for sure. First, the volcano had finally erupted (it had given off plenty of indications it would); and, second, the base had been evacuated. It wasn't until the first few days of the next week that telephone communications were reestablished with our counterparts who had returned to Clark. On Tuesday, 18 June, I first began to understand just how bad conditions were at Clark. On that day, the Deputy Chief of Supply was able to get through via phone. He described destruction that was hard to imagine—half of the supply warehouses had collapsed roofs, there was no electricity or running water, buildings were down all over the base, and the main base computer had flooded and water was coming out of the disk drives. While he tried to describe the devastation, his words did not convey the true magnitude of the disaster as much as his voice. I have known him since 1983, and he has always been one of those upbeat "make light of any adversity" type of guys. I'd never known him to be really down until I spoke with him on the phone that day. His sense of defeat came through loud and clear, and I knew then that we had our work cut out for us.

The most obvious problem was how to support Clark personnel with the supplies they needed to simply survive those first few weeks. From the day the volcano blew, the Standard Base Supply System ceased to exist at Clark. Most of the supply folks had been evacuated to Subic Bay; and, during those first few weeks, there were only 30 supply personnel at Clark and half of these were fuels types. (Manning ultimately peaked at around 90, but even then a number of these were assigned customs duties as the base personnel pitched in to support the pack-up of household goods and personal effects for all who had evacuated.) Besides the drastic reduction in personnel (supply manning had been close to 400), with the base computer destroyed, even emergency requisitions could not be processed. It was obvious Clark needed a lifeline to the outside world.

The PACAF staff decided to establish a supply task force at Kadena AB, Japan, to handle Clark's immediate requirements. We established an organization code on the Kadena system and loaded an initial $200 thousand of Clark's funds to meet the demands for survival and recovery supplies. The Kadena supply folks manned the task force initially. By 21 June, we had diverted the Clark Materiel Storage and Distribution Officer, who had been on leave in Korea, to Kadena to head up the task force. With a telephone link to the Kadena supply task force, the "Ash Warriors" of Clark now had their lifeline.

The initial requests coming out of Clark were quite revealing. They needed snow shovels (not too many in stock at Clark!) to remove the ash from the roofs of those structures still standing. With the rainy season approaching, the roofs had to be cleared or else the ash would soak up tons of water and the remaining roofs would surely collapse. They requested wheelbarrels, work gloves, honeycomb floor matting (to capture the ash at building entrances), squeegees, and rubber boots. They wanted any type of filter material to protect generators and air conditioners from the ash. Vehicle parts were also in great demand—filters, tires, windshield wiper blades, etc. The task force located the needed supplies in-theater and had them shipped via lateral support procedures to Kadena for consolidation and subsequent shipment to Cubi Point Naval Air Station in the Philippine Islands. From there they were trucked to Clark, as the runway was closed, never to be reopened. This task force concept was very successful in meeting Clark's immediate survival needs and continued to provide support for some time.

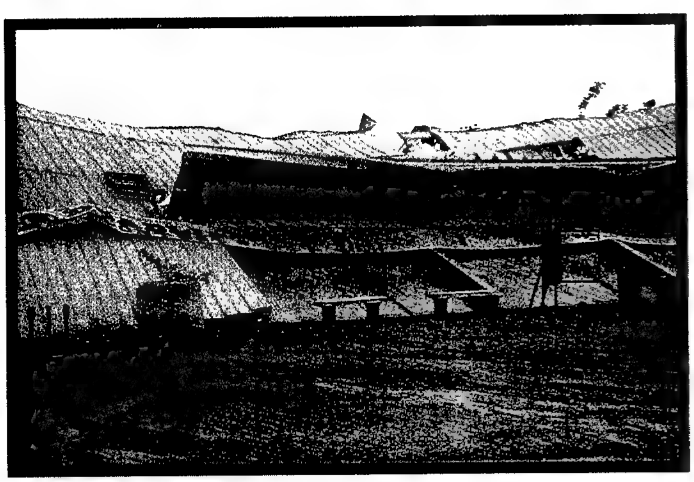
There was one commodity that Clark still had plenty of and that was petroleum, oil and lubricant (POL) products. One of the two power plants survived, and the base could generate all the power needed by the few hundred personnel who had remained at Clark. Distribution of the electricity, however, was a big problem as lines were down all over the base. Consequently, the 15 or so fuels troops worked 18-hour days delivering fuel to generators throughout the base to keep the power flowing, the lights on, and the recovery operation going. There were many heroes among the "Ash Warriors," and those fuels folks were critical until the power distribution problems were finally solved in July.

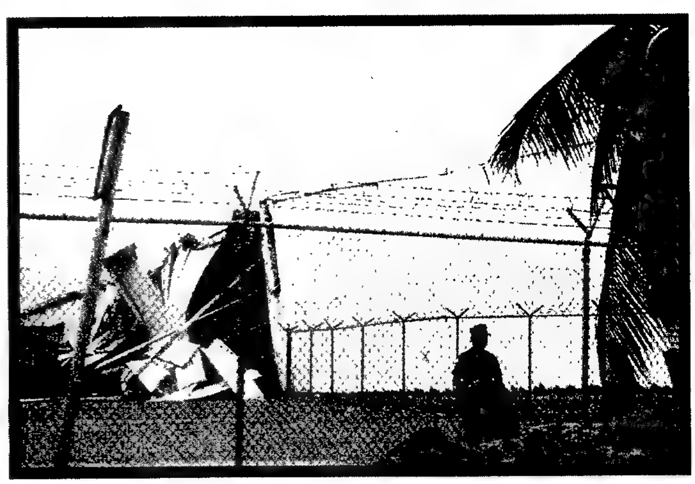
At the end of June, a headquarters team visited Clark to place a dollar value on the damage and determine the feasibility of salvaging the air base. This visit was a major reason the decision was made to end US presence there as soon as possible. It's interesting to note that, while supply's main administration building survived all that Mother Nature could throw at it—8 inches of volcanic ash, 5.0 plus earthquakes, and flooding—the structure didn't survive the scrutiny of the headquarters civil engineers. They determined that asbestos particles from old false ceilings, installed years ago, had been shaken loose by the earthquakes and were floating in the air! Consequently, the building was condemned and the supply operation had to be moved to one of the warehouses still standing.

So, what other actions did we take to support our forces marooned at Clark? By 21 June, we had established a project code of 639 for all Clark requirements. This was short-lived, however, as a JCS project code of 9CA was approved on 26 June by the Joint Chiefs of Staff for all Mount Pinatubo recovery operations. We directed that all shipments destined for Clark be held at both aerial and water ports. At places such as Kadena; Tinker AFB, Oklahoma; and Travis and McClelland AFBs, California, the materiel began to pile up. All Clark requisitions were placed in a hold status. Since the final decision on Clark's future had not been made, we didn't cancel requisitions or

An airman shovels ash from a roof before the rains.

Below: Unbelievable destruction of base buildings caused by a combination of ash and rain.





redirect property already in the pipeline. That was to come later. During this time, about all we could do was meet immediate survival needs and develop support plans and concepts based on various scenarios for Clark's future.

In early July, we began to move assets out of Clark. We directed the movement of three Weapons Training Detachment Operating Spares (WTDOS) kits for the A-10, F-15, and F-16 to other PACAF bases. It was obvious that, even if the decision was made to recover Clark, the resumption of flight-line operations was months away. More importantly, supply needed the WTDOS warehouse as a staging area since the primary focus of operations shifted from the acquisition of relief supplies to the recovery of serviceable items from the collapsed warehouses.

The local civil engineers began to dismantle the first warehouse in late July while we made arrangements for a 17-man Rapid Area Distribution Support (RADS) team from the Air Force Logistics Command (now Air Force Materiel Command) to assist in salvaging the inventory. They arrived in August and were a tremendous help in recovering most of the Clark inventory.

Even with the additional RADS personnel, the number of supply people available to recover, identify, label, pack, and ship most of Clark's inventory was small. Further, without an administrative building available or an on-line database, the Chief of Supply requested a single shipping destination to ease the workload on his meager workforce. Andersen Air Force Base, Guam, was selected to receive and in-process Clark's inventory; and by 8 August, we had established a satellite account at Andersen to receive the vast majority of Clark's property. Selected items, such as classified components and small arms weapons, and large components, such as R-9 refuelers, liquid oxygen (LOX) tanks, mobility bags, and support equipment, were shipped to bases other than Andersen; but we tried to keep such exceptions to a minimum.

While heavy rains in August delayed the dismantling of the warehouses and the recovery of the assets, we made tremendous progress in recovering Clark's inventory. Even though the initial direction had been to concentrate on high-value items, ultimately over 90% of Clark's on-hand inventory was recovered and shipped. Even storage aids were salvaged and shipped to four PACAF bases, including Andersen. Shipping documents were limited to DD Forms 250 for item identification and DD Forms 1149 for shipments. By 4 November, the recovery of Clark's inventory was declared "complete."

Meanwhile, with the decision to abandon Clark, all requisitions that had been placed in a hold status were mass canceled. Direct shipments from contractors could not be canceled, so the Clark stock fund paid these bills on good faith that the assets had been shipped and, while they most probably never actually reached Clark, they were in Air Force transportation channels someplace. All assets that had been building up at various aerial and seaports were directed to the nearest Air Force supply account for receipt processing.

The recovery of jet fuel at Clark presented some unique challenges. While the inventory had been drawn down as part of the conversion from JP-4 to JP-8, over three million gallons of jet fuel were on hand. Another million plus gallons of motor gasoline (MOGAS) and diesel were also at Clark. The tanks and on-base fuel lines survived the eruption and the many earthquakes. However, the pipeline between Clark and Subic was washed away at two river crossings. The mud and ash-swollen rivers were too much for the pipeline support structures. Therefore, the initial plan had been to sell the fuel in-place to the Philippine government.

However, by the first of October, Mt Pinatubo changed all that. The volcano had continued to spew out ash since the initial eruption; and, with the coming of the rainy season, mud flows became a very serious problem. We estimated that the ash was hundreds of feet thick in the mountains, and the rains began to move this "new earth" down upon Clark. It soon became obvious that these mud flows might very easily reach the POL tank farm. If this happened, the tanks would surely rupture and the million gallons of jet fuel, MOGAS, and diesel would flow right through the middle of Clark and then into Angeles City, the local Filipino community. This catastrophe had to be avoided if at all possible. The suggestion was even made that the fuel should be burned in the tanks. My fuels experts quickly "snuffed out" that idea. They predicted that, even if those selected to ignite the fuel survived, the fire itself would rupture the tanks, and then burning fuel would engulf Clark and Angeles City! Another solution had to be found.

With the pipeline between Clark and Subic out and basically inaccessible, the only possible solution was to truck the fuel to Subic. Local contractors were found and hired and soon had fourteen 10K-, 8K-, and 5K-gallon trucks hauling fuel to Subic. With most of the major bridges out between Subic and Clark, this was not an easy task. By mid-October, however, over two million gallons of jet fuel and MOGAS had been transferred. The contractors would have moved more, but some of the tank bottom fuel was inaccessible because mud flows had already covered the tank bottom drains.

Simply getting the Clark inventory evacuated was really only part of the problem. A total of 490 Sealand vans or equivalent bulk shipments ultimately reached Andersen AFB. The struggle to sort through Clark's inventory at Andersen, receipt it into the satellite account, process it to the Defense Reutilization & Marketing Office (DRMO), or ship it out is another interesting story. Clark's database was loaded at Kadena and, whenever possible, shipments were processed against it to reduce the inventory balances. Shipments were definitely processed for all weapons and classified assets. Once all possible processing was complete, the remaining balances were inventory adjusted using transaction code G (major loss due to acts of God, major disasters, fire, or wartime).

Given the chaotic conditions of Clark, certainly there were items that were stolen or simply disappeared. However, a large percentage of forces that remained to close Clark AB were security personnel, so the base was relatively secure after the first few days. Nevertheless, an accurate accounting of what was actually stolen versus simply abandoned, due to damage from structural collapse of the warehouses, water, or ash, was impossible. On 4 November, I granted waiver authority for obtaining signatures on Clark's final M-10, and by Thanksgiving the base was turned over to the Philippines. The closure of what had been one of PACAF's busiest and most beautiful bases was accomplished with dignity in the face of constant threats from volcanic eruptions, earthquakes, flooding, and mud flows. I salute the "Ash Warriors" who made it happen!

Putting AMC Technology to Work

Albert S. Hoover

This paper describes how advanced materials technologies are being used by the San Antonio Air Logistics Center, Technology and Industrial Support Directorate (TI), to improve the reliability and maintainability of Air Force Materiel Command (AFMC) managed weapon systems. Materials technologies are a valuable asset that contributes immensely toward the support of logistics. Following is a brief synopsis of one ongoing materials project, sponsored by the Advanced Metals and Ceramics (AMC) Technology Application Program Management (TAPM) office, that best exemplifies the meaning of putting technology to work.

Introduction

The AMC TAPM office mission is to stimulate awareness of the benefits of advanced metals and ceramics by acting as a proponent of the technology. This goal is achieved through the institution of three main program objectives:

(1) To accelerate the transition of mature laboratory technologies to Air Force weapon systems to improve reliability and maintainability.

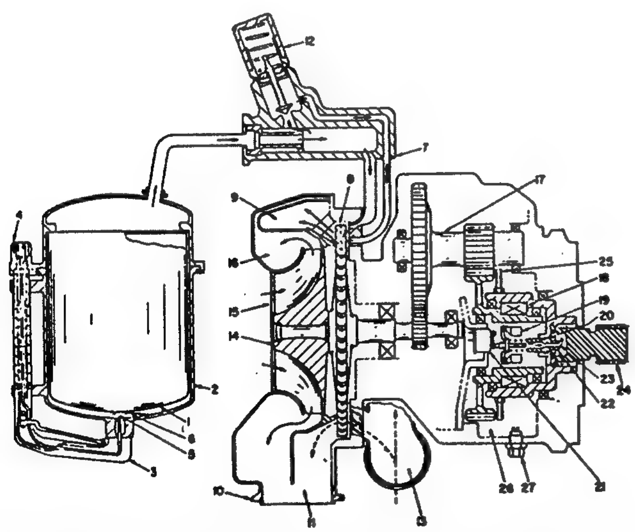
(2) To transition technology from expertise developed and through technology insertion projects.

(3) To develop Materiel Command AMC support capability.

On September 1990, this office initiated a technology insertion project to resolve corrosion problems inherent to the cartridge pneumatic starter breech caps of the B-52 aircraft. The current breech cap design incorporates an electroless nickel-plating system that has reportedly been known to fail (corrosion formed) after just three cartridge firings. The goal was to develop a coating system using AMC technology that would sustain 15 test firings with no subsequent corrosion. They believed that thermal barrier coating (TBC) technology using advanced ceramics was the answer to the problem.

Background

A cartridge pneumatic starter is a pressurized mechanical system used to accelerate jet engine turbines to a rotary speed sufficient to start the engine (Figure 1). The starter operates in two modes: the cartridge mode and the pneumatic mode. The cartridge mode uses a rapidly burning solid propellant charge



Schematic of functional starter components

1. Cartridge
2. Breech cap
3. Breech handle
4. Connector
5. Ignition contact
6. Ground clip
7. Hot-gas nozzles
8. Turbine rotor
9. Turbine exhaust ring
10. Overboard exhaust connector
11. Exhaust from turbine and fan
12. Relief valve
13. Compressed-air inlet
14. Aerodynamic-braking fan
15. Air inlet for braking fan
16. Fan exhaust ring
17. Gearshaft
18. Overrunning sprag clutch
19. Flyweight
20. Switch actuating rod
21. Switch
22. Adjusting screw
23. Gearbox vent
24. Spline shaft
25. Oil slinger
26. Oil sump
27. Magnetic plug

Figure 1. Cartridge pneumatic starter.

enclosed in a breech chamber/cap assembly to produce gases for the energy to alert start the aircraft engine. In the pneumatic mode, air from another engine or ground support compressor provides the necessary energy. The cartridge mode has two distinct advantages for military aircraft. First, it provides a self-sufficient starting capability not dependent on ground support. Second, it provides a quick start capability, in which all engines can be started simultaneously, an advantage under alert conditions.

The cartridge pneumatic starter breech cap has a corrosion failure history since before 1978 (Figure 2). The premature failures of steel breech caps have been prevalent enough to cause serious concerns. The problem is in the areas of the internal surfaces. The internal surfaces are heated during cartridge firing to a point where the protective metallic coating fails and exposes the steel substrate to galvanic dissolution. The evidence suggests that this leads to a corrosion process which is a continuing one and that much of the damage is produced by the environment present between firings. This then results in a condition of severe pitting on the interior surface of the breech cap which leads to a reduction of wall strength integrity.

Figure 2. Electroless nickel coated breech cap (showing corrosion).

Technology

The state-of-the-art TBC developed for combustion components that can achieve both temperature reductions and oxidation resistance consists of a metallic inner layer and an outer insulating ceramic layer. The inner metallic layer of the TBCs, the bond coat, is a plasma flame sprayed cobalt-chromium-aluminum-yttria (MCrAlY) composite superalloy approximately 0.005 inches thick. The bond coat provides oxidation resistance for the metal component and serves as a rough surface for ceramic adherence. Also, it provides the thermal cushion necessary for thermal expansion of two dissimilar materials. The ceramic layer, or top coat, is a plasma flame sprayed zirconia ceramic partially stabilized with yttria approximately 0.005 to 0.015 inches thick. The ceramic layer reduces the heat transfer to the metal component.

Test Procedure

Three breech caps, each having a different coating system, were evaluated in the starter test cell program. The first breech cap was coated with a MCrAlY bond coat only (Figure 3) and the second with a MCrAlY/zirconia TBC system (Figure 4). The third breech cap was coated with the originally designed electroless nickel-plating system in order to have a standard for comparison. All breech caps were test fired following, as close as possible, identical test cell conditions. A minimum of one-half hour was allowed between test firing of each breech cap. Operational temperatures and pressures were recorded for test data. After each firing, the breech caps were examined for coating failures. The two AMC coated breech caps were test fired 15 times and the standard breech cap 3 times.

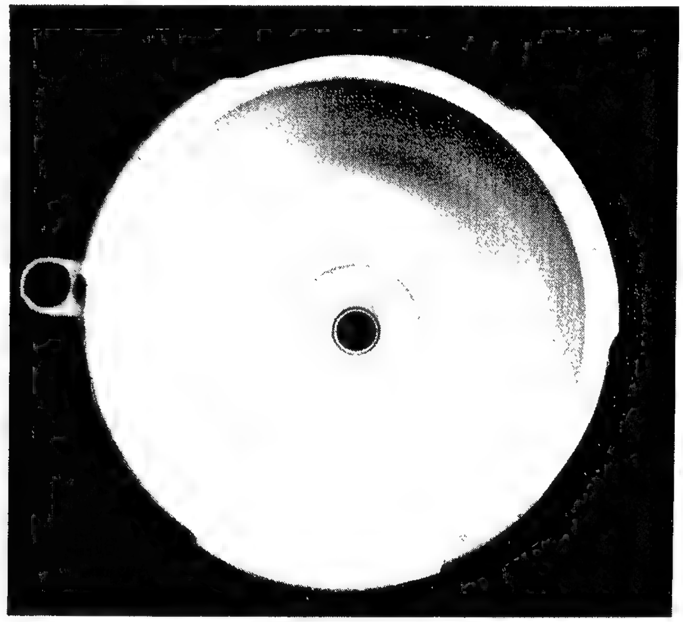


Figure 3. MCrAlY coated breech cap.

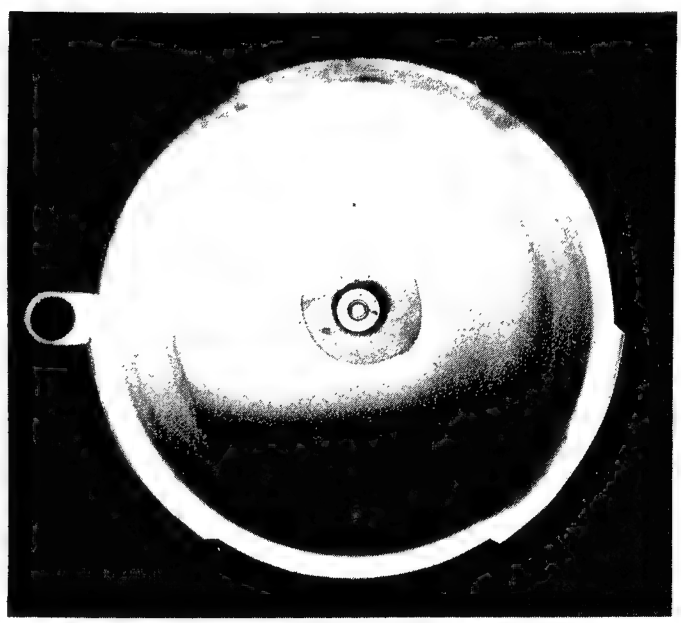


Figure 4. Ceramic coated breech cap.

Test Observations

Test firings lasted about 18 to 20 seconds with operating pressures reaching approximately 800 psi. Breech cap outer shell temperatures ranged from 293° to 533° F. Residual buildup of spent cartridge combustion by-products was noticeable after each firing. No coating deterioration was observed after each test fire for all three breech caps. All test cartridges successfully fired and provided the necessary energy to operate the starter. All the required pressure, torque, and RPM variables for normal starter operation were met.

Conclusion

The two breech caps using the AMC coating technology sustained 15 test firings with no signs of coating failure for an observation period of 6 months after the last test fire. The standard electroless nickel breech cap, that had been test fired only three times, showed signs of corrosion after just one week of storage. Test results indicate that either AMC coated breech cap design would resolve the corrosion problem. However, since temperatures measured in the breech caps during firing were not found to be very high (max of 533° F.), the TBC ceramic coating is not justifiably needed. The MCrAlY bond coat will meet the corrosion and temperature requirement necessary to sustain the operating environment of the alert starter system.

Summary

Successful completion of the TBC ceramic project will provide the Air Force with a more reliable and maintainable emergency starter system. This reliability enhancement translates into cost and labor savings due to the fivefold extended life expectancy of the breech caps. This is especially important at a time when the Air Force is experiencing limited budgets in order to maintain their weapon system fleets. The value of this TBC project is not the improved coating system for an old problem, but the potential applications that are starting to occur as a result of the effort. Experience with this technology can be applied to other combustion components within Air Force weapon systems that are encountering similar high temperature corrosion problems.

Sources

1. Anderson, J. A., and Galasinski, C. R. "Jet Engine Starters, Cartridge Pneumatic," ASME Publication 67-GT-49, pp. 1-14.
2. Perkins, Phillip C., Daniels, Raymond D., and Gillies, A. Bruce. "Failure Analysis of Steel Breech Chambers with Aircraft Cartridge Ignition Starters," AF Publication 8517-005, pp. 143-146.
3. Brindley, William J., and Miller, Robert A. "TBCs for Better Engine Efficiency," *Advanced Materials & Processes*, Volume 136, Issue 2, August 1989, pp. 29-33.

The original version of this article appeared in the 27th Annual International Logistics Conference Proceedings of the Society of Logistics Engineers (1992).

Albert Hoover is presently an engineer in the Engine Test, Engineering and Planning Directorate, San Antonio Air Logistics Center, Kelly AFB, Texas.

Most Significant Article Award

The Editorial Advisory Board has selected "The Theory of Constraints Approach to Focused Improvement," by Major Jacob V. Simons, Jr., USAF, and Lieutenant Colonel Richard I. Moore, Jr., USAF, as the most significant article in the Summer 1992 issue of the *Air Force Journal of Logistics*.

Medical Stockless Materials Management: Applications for the USAF Medical Service?

Captain Thomas M. Harkenrider, USAF

Background

The Air Force Medical Service (AFMS) faces a steadily increasing demand for its services, yet plans to operate on fairly stable budgets. In other words, the Service will have more patients to treat, without an increase in funding to take care of them. If patient services are to remain at current levels, senior leadership in the Medical Service must look for ways to control costs. Among medical treatment facility (MTF) costs, medical supply costs represent the largest single element of the MTF's operation and maintenance (O&M) budget. For example, the USAF Medical Center, Wright-Patterson AFB, Ohio, spent more than $19 million or 46% of its O&M budget on medical supplies in FY90. (8:36) In FY90, the Medical Service as a whole spent 38% of its O&M budget on medical supplies. (10) In comparison, in 1989, civilian hospitals spent 17% of their budget on medical supplies. (6:16) The reason for the major difference between the two percentages is because the Air Force operates an outpatient pharmacy and a dental clinic in its MTFs, and civilian hospitals do not. Finally, the MTF budget does not reflect salaries for military personnel.

Since medical supply costs are a significant part of the operating budget, in both military and civilian facilities, healthcare executives are continuously seeking ways to control these costs. In recent years, civilian hospitals have found they can decrease their medical supply costs by implementing stockless materials management systems.

Definitions of Just-in-Time (JIT) and Stockless Materials Management

JIT

The medical literature shows that stockless materials management is an application of JIT. Developed in Japan, JIT is a simple concept. Basically, it means producing small quantities "just in time." In his book, *Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity,* Schonberger states:

> Produce and deliver finished goods just in time to be sold, subassemblies just in time to be assembled into finished goods, fabricated parts just in time to go into subassemblies, and purchased materials just in time to be transformed into fabricated goods. (11:16)

Schonberger further notes:

> The JIT ideal is for all materials to be in active use as elements of work in progress, never at rest collecting carrying charges. It is a hand-to-mouth mode of operation, with production and delivery quantities approaching one single unit piece-by-piece production and material movement. (11:16)

However, Schonberger finds "like perfect quality," absolute just-in-time performance is never attained. Rather, it is an ideal to aggressively pursue. (11:16)

As implied from this definition, JIT has its base in a manufacturing environment and has application in service processes as well. JIT focuses on processes, not products. (2:776) Chase and Aquilano further state that JIT has application in any process and definitely can, and does have, application in hospitals.

Stockless Materials Management

Unlike JIT, stockless materials management seeks to eliminate the hospital's central storeroom inventory, not just reduce it. (5:III-11) Under stockless materials management, distributors operate a pick-and-pack operation for the hospital. They deliver supplies directly to the using activities in the facility. As a result, there is no need for a warehouse or central distribution function within the facility. These functions are performed at the distributor's facility. In other words, with stockless materials management, the supplier acts as the hospital's warehouse as well as the central distribution function. Conversely, under JIT, the supplier acts as the hospital's warehouse only. Figure 1 illustrates the differences between conventional supply, JIT supply, and stockless materials management supply.

Hall, sharing the same opinion as Schonberger, says in his book, *Zero Inventories*: "Zero inventories connotes a level of perfection not ever attainable in a production process." (4:11) Hall goes on further to note: "It [stockless production] is not an end in itself because the pure ideal cannot be literally attained." (4:2) In other words, it is something which hospitals should "shoot for."

Stockless Materials Management/JIT Confusion

The medical literature also reveals that, in the healthcare environment, there is confusion in distinguishing between JIT and stockless materials management. Some hospitals state they are stockless, when, in fact, they are only using JIT procedures. (6:22) The 1990 HIDA study surveyed distributors, and 82% agreed with the following stockless materials management definition:

> In a stockless program, the distributor takes over the hospital's central distribution function (i.e., the "pick-and-pack" operation). The distributor delivers products in "eaches" (singles), sorted by user department, to the hospital receiving dock where they are transported directly to the departments, usually on a daily basis. (6:23)

General Benefits of Stockless Materials Management

For a civilian hospital to increase its net profit by $250,000, it would have to increase revenues by $8 million. (6:11) Others find that it would take almost $12 million in revenues to increase the net profit by $100,000. (9:71) Both examples show that it is difficult for hospitals to increase their profit by increasing revenues. Therefore, hospitals have found that cost containment is a more productive method and that stockless materials management is one such method that can achieve tangible savings. Stockless materials management offers the following benefits to any hospital, regardless of size:

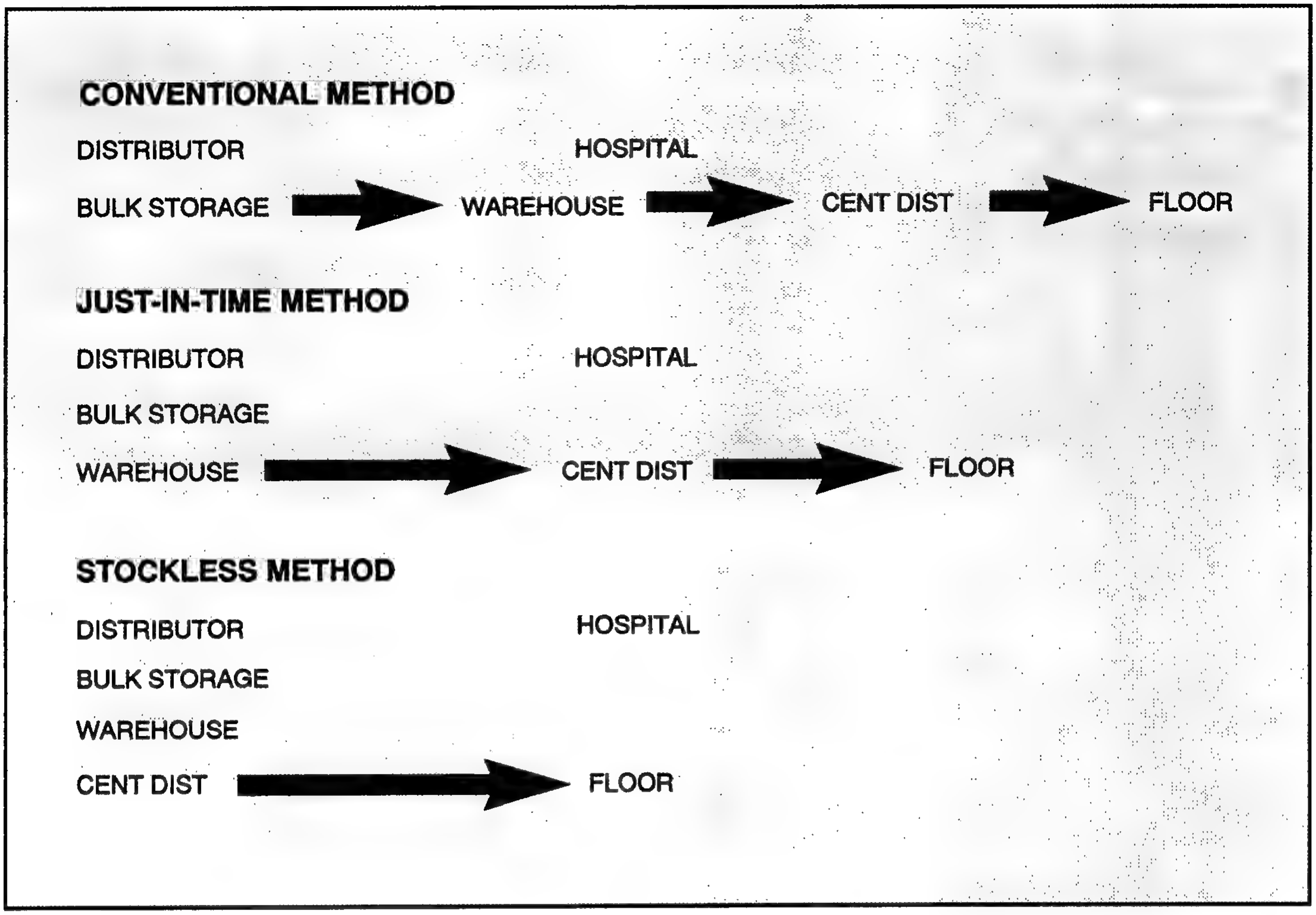


Figure 1. Conventional Supply vs JIT Supply vs Stockless Materials Management Inventory Supply Systems.

(1) Reduced inventory and related carrying costs (both in official and unofficial inventory).

(2) Reduced employee costs, in both direct (supply personnel) and indirect (nursing, accounting, etc.) areas.

(3) Reduced warehouse requirements.

(4) Increased revenues.

(5) Reduced transaction processing costs.

(6) Lower product costs.

(7) Better service to user departments. (6:11-12)

These benefits are a direct result of the following factors:

(1) A distributor has a 10% to 15% lower labor cost.

(2) In terms of facility space, cost per square foot is generally higher in a hospital than for a distributor.

(3) Distributors have better systems to support inventory control and higher fill-rates.

(4) Distributors are able to leverage their operations over a much larger customer base. (6:12)

The literature review shows that stockless materials management has widespread applicability and has potential in any size facility.

Methodology to Convert to Stockless Materials Management

All hospitals are potential candidates to become stockless hospitals. However, not all hospitals are ready to try stockless materials management implementation. The medical literature provides several methodologies for evaluating a hospital's candidacy for conversion. (6:43-46; 12:27-28; 7:6; 4:258) The HIDA methodology is the most comprehensive and involves a four-stage, successive approach: internal focus, product focus, supplier focus, and delivery focus. Do Air Force MTFs meet the criteria to implement stockless materials management? A review of the four HIDA phases answers this question.

(1) *Internal Focus.* Before a hospital can implement stockless materials management, good materials management practices and procedures must be in-place. The internal focus occurs solely within the hospital with no outside (supplier) help. These good materials management practices emphasize that all purchasing must occur within one accountable department, written policies concerning employee duties and behavior must exist, an environment for methods improvement must exist within the organization, inventory control must be computerized, and supplier selection must consider factors beyond cost.

In Air Force MTFs, all purchasing occurs in one accountable area—medical supply. The Air Force uses a highly sophisticated and automated inventory control system: the Medical Logistics (MEDLOG) system. MEDLOG controls all in-house inventory, tracks all due-in inventory, requisitions supplies, and expenses supplies to the MTF. For the most part, the Air Force uses the lowest bidder concept. However, in recent years, additional factors, such as contractor performance and packaging, are also included in the purchasing decision. Most Air Force MTFs meet the requirements of the internal focus phase.

(2) *Product Focus.* During this period, a hospital-wide "corporate program" evaluates the products within the facilities to find out:

a. How products are purchased and from whom.

b. What benefits the facility receives by buying a particular product from a particular source.

c. Which product packaging is most beneficial to the facility.

d. If products are standardized to avoid carrying the same items under different labels.

How products are purchased and from whom are issues addressed at levels above the individual MTF. For example, on depot items, the Defense Logistics Agency (DLA) purchases the items and, in doing so, seeks favorable pricing and payment terms. As a result, DLA has preferred suppliers; and those preferred suppliers receive a greater volume of business from the Agency. The end result: Air Force MTFs receive the benefits of the efforts of organizations above it.

Product evaluation is also accomplished at levels above the individual MTF. Most product evaluating and standardizing for DOD are conducted at the Defense Medical Standardization Board (DMSB). However, some product evaluation occurs in the local MTF; for example, pharmaceuticals. In the MTF, there is a committee that reviews pharmaceutical use and stocking. Additionally, nursing personnel seek to standardize typical nursing supplies used in the MTF. For the most part, Air Force MTFs meet the requirements of the product focus phase.

(3) *Supplier Focus.* Many consider this the most difficult step in the entire process. In this stage, a partnership is developed between the facility and a preferred supplier. During this period, the hospital addresses the following areas:

a. Consolidation/selection of supplier. Here the hospital selects a prime supplier. The objective is to gain control over the supply operation by reducing the number of suppliers. If the "right" supplier is selected, the facility's operation becomes more efficient. Typically, the selection criteria are supplier size, performance, and reputation.

b. Use of electronic data interface (EDI). Benefits of EDI are no manual processing of purchase orders, elimination of transcription errors, and real-time processing and verification. Also, the information is more timely and accurate.

Supplier selection is an area where the Air Force remains weak. Even though factors other than price are now considered, price still remains the predominant factor in the purchasing process.

Air Force MTFs are using EDI with MEDLOG to accomplish requisition actions with DLA. This interface is also used for payment processing with accounting and finance, and between the MTF and the host-base contracting facility for local purchase ordering.

For the most part, Air Force MTFs meet the requirements of the supplier focus stage.

(4) *Delivery Focus.* The first three stages set the foundation for this final focus which seeks one of two primary delivery objectives: JIT or stockless materials management. In this stage, actual delivery under a stockless system is created and implemented. Here is where the medical staff gains confidence in the stockless system.

The Air Force is ready, on the surface, to enter this final stage. Yet, there are some concerns that require addressing. These concerns, however, do not involve the physical (operational) requirements of implementing stockless materials management. They involve the wartime requirements of the AFMS (discussed later).

Specific facilities may not (for other reasons) be ready to implement stockless materials management. However, the Air Force Medical Service, as a whole, meets the requirements of the HIDA methodology to convert to stockless materials management.

Is Stockless Materials Management Already in Use in the Medical Service?

An argument can be made that postulates there is already a stockless materials management program in use in the Medical Service. At most Air Force MTFs (116 out of 132), there is a medical stock record account (FM account). A stock record account, part of the defense business operations fund (DBOF), acquires medical supplies for the host facility. The DBOF is a revolving fund; i.e., it buys supplies (from DLA, local purchase, etc.) and sells those supplies to the MTF. The MTF does not own the supplies until they are purchased from the supply account. O&M funds are not involved in funding the inventory. As a result, the FM account acts as the prime vendor for the MTF. One of the cornerstones of the stockless system is a prime vendor relationship between the hospital and a supplier. Using the FM account approach, the Air Force currently meets that requirement.

As a matter of policy and practice, the inventories maintained in the MTF (the unofficial inventory) are kept to a minimum. No more than two weeks' worth of recurring supplies are in the facility. Again, as a matter of policy and practice, for most activities, that amount is much less. For example, under the internal distribution operation (IDO), routine supplies are delivered to IDO customers by a predetermined delivery schedule (usually daily, two times, or three times weekly). IDO is mandated for use in clinics, hospitals, and regional hospitals. For Air Force medical centers, central processing and distribution (CPD) is used. CPD is basically the same as IDO, except that it includes sterile goods and uses an automated accounting system. In both IDO and CPD, the supplies are issued in adjusted units of issue, usually "eaches." With regard to the accepted stockless definition, ". . . distributor delivers products in 'eaches' [singles] . . . directly to the departments, usually on a daily basis," the IDO and CPD process meet the definition of a stockless materials management system.

Recalling the general benefits of stockless materials management, IDO and CPD achieve some of these same benefits: the reduction of involvement of nursing personnel, the reduction of unofficial inventory, and better service (fill-rate) to the user departments.

Based on this discussion, it is fair and accurate to assert that the existing Air Force medical supply operation resembles a stockless materials management system. The existing Air Force medical supply system has many of the characteristics found in a stockless system.

Concerns About Implementing Stockless Materials Management in AFMS

Aside from the previously mentioned differences (the military's operation of an outpatient pharmacy and a dental clinic), the day-to-day operations of the military system and the civilian system are similar. In both systems, medical supply costs represent a sizeable expense of the host facility. It has been shown that an argument exists that the AFMS currently operates a "hybrid" stockless materials management system. However, there are some areas where the two systems differ; and these

differences need addressing prior to the Air Force implementing a "true" stockless materials management system.

The Medical Service maintains large amounts of medical war reserve materiel (WRM)—more than $203 million. (1) By regulation and as a matter of practice, WRM (especially that with an expiration date) is commingled with the operating stock. This helps ensure the rotation of the WRM stock. With a stockless materials management system (or a JIT system), there is no operating stock with which to commingle the WRM. If the Air Force plans to use stockless materials management, the issue of how to store the WRM must be resolved.

In civilian hospitals, stockless materials management and a reduction of medical supply personnel simply represent a decrease in supply costs (this is what the hospitals want). Furthermore, in facilities that account this way, the cost of the supply is passed directly on to the patient. So if it costs more to buy an item via stockless, and the cost of the item is passed on, the facility enjoys a double savings. It has decreased manpower costs, and the cost of running the stockless system is passed on to the customer. The Air Force Medical Service does not account this way; there are no paying patients to pass the cost on to.

In the Air Force, a reduction in medical supply personnel represents much more than a reduction in manpower costs. It also represents a potential degradation of the Medical Service's wartime readiness capability. In addition to peacetime day-to-day duties, medical supply technicians have a significant wartime mission to support both deployed and home-based medical units. In fact, over 80% of all Air Force medical supply technicians are assigned against mobility positions. Implementation of stockless materials management must not impair the ability of the Medical Service to meet its wartime mission.

Conclusions

Stockless materials management systems, as developed by civilian hospitals, are currently partially modeled and implemented by Air Force MTFs. These management systems have the potential to be fully modeled and implemented successfully by the Air Force Medical Service. Tangible savings to be gained by implementing stockless materials management are found in reductions in a facility's manpower, official inventory, and warehouse requirements. Several intangible benefits are a decrease in the number of suppliers to the facility, an increased fill-rate to the customers within the facility, and decreased destruction of expired medical supplies.

There are still several issues that require resolution before stockless materials management can become a reality in the Medical Service. Primary among these concerns is that stockless materials management will be at the expense of skilled medical supply technicians. Stockless materials management represents "efficiency" in medical supply operations; efficiency is sought in a peacetime Air Force. In a wartime Air Force, "effectiveness" is what is required in medical supply operations. If stockless materials management is to be implemented in the Medical Service, steps must be taken to ensure that the efficiency of the peacetime Air Force does not affect the wartime effectiveness.

Recommendations

After analyzing all the advantages and disadvantages of the stockless materials management system, I recommend that the Air Force Medical Service implement selected aspects of stockless materials management. I believe stockless can help control medical supply costs in the future and, at the same time, allow the Medical Service to meet its mission—to provide the best healthcare possible to Air Force members.

References

1. Air Force Medical Logistics Office (AFMLO). Medical/Dental Stock Fund (MDSF) Statistics, AFMLO/FOS, Frederick MD, January 1991.
2. Chase, Richard B., and Aquilano, Nicholas J. *Production and Operations Management: A Life Cycle Approach*, Homewood IL: Irwin, 1989.
3. Department of the Air Force. AFM 67-1, *Air Force Medical Materiel Management System*, Vol V, Washington DC: HQ USAF, May 1987.
4. Hall, Robert W. *Zero Inventories*, Homewood IL: Irwin, 1983.
5. Health Industry Distributors Association (HIDA). *From Producer to Patient: Valuing the Medical Products Distribution Chain*, Washington DC: HIDA Educational Foundation, 1987.
6. Health Industry Distributors Association (HIDA). *Stockless Materials Management, How it Fits into the Healthcare Puzzle*. Alexandria VA: HIDA Educational Foundation, 1990.
7. Kowalski, Jamie C. "Just-in-Time for Hospitals - So What's New?" *Hospital Materials Management*, 11 (November 1986), pp. 6-9.
8. Medical Resource Management Office (MRMO). "The Big Picture: Management Summary," *Quarterly Management Report*, USAF Medical Center, Wright-Patterson AFB OH, August 1990.
9. Pettus, Michael R. "JIT/Stockless Programs for Hospitals," *Federation of American Health Systems Review*, 23 (March/April 1990), pp. 71-73.
10. Polson, Stanley M., Health Financial Management and Staff Officer, telephone interview, Office of the USAF Surgeon General, Bolling AFB DC, 18 January 1991.
11. Schonberger, Richard J. *Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity*, New York NY: The Free Press, 1982.
12. Wagner, Mary. "Stockless Inventory: Some Say It's a Hot New Innovation, But Skeptics Don't Put Much Stock in Its Claims," *Modern Healthcare*, 20 (2 April 1990), pp. 22-28.

Captain Harkenrider is Medical Logistics Staff Officer, AF Medical Support Agency, Brooks AFB, Texas.

Medical Diagnostic Imaging Support (MDIS) System - The DOD Medical Service Leads the Way!

Lieutenant Colonel Anthony Gelish, USAF, MSC

Introduction

This paper first describes technological advances in the healthcare community and then discusses optimized logistics with specific problems experienced in the medical imaging environment. Next, it introduces four core technologies to improve the availability of medical imaging information. Then, it describes several problems DOD faces in the areas of radiologist shortages, mobile beneficiary population, and battlefield imaging resourcing, and shows how the Medical Diagnostic Imaging Support (MDIS) System can solve those problems. It concludes with a recommendation to analyze the benefits of new technologies, such as MDIS, to improve medical logistics throughout DOD.

Advancing Technology

During the last few years, the healthcare community has assimilated many technological advances benefiting diagnostic, palliative, and rehabilitative healthcare:

Diagnostic Information

Past "high tech" discoveries improving diagnostic information for healthcare providers include computerized tomography (CT; three dimensional imaging using ionizing radiation), magnetic resonance imaging (MRI; three dimensional imaging using magnetic fields induced in the body), single photon emission computed tomography (SPECT; a more precise version of CT), ultrasound scanners (US; the use of reflected sound waves to create an image), and positron emission tomography (PET; images created from detection of the deterioration of injected radionuclides). Each technology provides improved noninvasive imaging of somatic structures and tissues within the body. Technological breakthroughs include the pairing of computers with such clinical laboratory equipment as cell counters, blood gas analyzers, radioimmunoassay analyzers, and spectrophotometers to provide rapid, high-volume analysis of body fluids (blood, urine, etc.) and results reporting.

Palliative Care

Significant advances in palliative care include cardiac pacemakers, implanted insulin pumps, transcutaneous electrical nerve stimulators (TENS) for pain management, and electrical bone growth stimulators to speed healing of fractures. Another advance includes medical applications for light amplification by simulated emission of radiation (LASER). Physicians use LASERs for a multitude of surgical applications, especially ophthalmic and obstetrical procedures. Their advantages include precision, tissue selectivity, and simultaneous cutting and cauterization.

Rehabilitation

The healthcare community has seen the incorporation of silicon chips and computers in simple equipment items for post-operative rehabilitation, including ergometers (used by cardiologists and internal medicine physicians for stress testing of cardiac patients), isokinetic exercisers (used by physical therapists to restore range of motion in damaged limbs), and other devices.

These benefits are only a sampling of how technological advances help improve life quality and length. However, until now, logistic's role in these medical improvements has been solely that of the equipment purchaser. Medical logistics can be of greater service if we accurately perceive the impacts of medical logistics management and technological advances within the healthcare environment and their associated opportunities.

Medical Logistics

Logistics is:

> . . . the management of physical and informational flows of products and services and of all activities related to these flows. (2)

Management is, quite simply:

> . . . meet(ing) product and related information flow requirements at a reasonable cost. It is a systems approach to the coordinated management of physical movement of goods and associated informational flows as well as related activities; logistics is designed to meet customer and firm needs in an efficient, effective manner, taking into account service and cost considerations. Recognized as a service function the logistics concept attempts to provide the highest level of customer service consistent with the cost of providing that service. (2)

Under these definitions medical logistics management is the cornerstone of healthcare. The only activity not included in these sweeping definitions is the physical work performed by the healthcare staff.

Optimized Logistics Approach

The medical community is inclined to "subsystem optimization" (2) or a fragmented approach to management of these product movements and related activities. First, in order to maximize system goals, an optimized ". . . logistics concept addresses itself to overcoming these weaknesses . . . by a systems approach." (2) Second, there are common areas of interest within units of the ". . . healthcare delivery system whose goals can be combined to optimize the system." (2) Third, an effective logistics system ". . . is designed to meet the demand of the . . . customers as well as the need of the other functional departments." (2) The medical community has been slow to recognize these principles and their direct patient care impacts. Logistics has tended to hard goods issues (timely and economical acquisition of supplies and equipment) and has taken little notice of how these principles impact patient care. "Placing the proper tools when and where required is pure logistics." (2)

Medical Imaging

Medical imaging is an area ready for an optimized logistics approach. Medical imaging has three major logistics problems: processing and storage of analog film; long-term storage of film images, including lost, misplaced, and stolen film; and access limitations for multiple healthcare providers and functional medical activities.

Processing and Storage of Analog Film

Processing and storage of hard copy analog film images are expensive and inefficient. The American College of Radiology (ACR) requires retention of all analog film images (plane film, computerized tomography, ultrasound scanners, magnetic resonance imaging, positron emission tomography) in active files for five years from the date of imaging; physicians should retain all films from birth to age 18 years and all mammographs until the patient is deceased. The resulting required storage space is enormous. On average, physicians recall only 1-per-1000 film images for review in the outpatient clinic environment within 7 days of imaging and within 30 days of inpatient discharge. (NOTE: This probability is higher for mammographs since previous image review is necessary to detect any minute, subtle changes.) (1) This resulting large storage volume leads to the second problem.

Long-Term Storage of Film Images

A large volume of hard copy analog film files increases the opportunity for misplaced images. This problem grows when healthcare providers retain films for their teaching files or reference, and when patients retain films for fear their images will be lost in storage. Maintaining images outside the storage system results in films being unavailable for subsequent review, comparison, and documentation of the appropriateness of diagnosis and treatment. As a consequence, these missing films create difficulties for the Quality Assurance Program. The Quality Assurance Program review of provider's healthcare actions ensures those actions were in the best interest of the patient. Peer review of healthcare relies heavily on the analysis of treatment record information. A missing film limits the reviewer's understanding of diagnostic and treatment decisions. When a provider needs to review images for further care, a missing film may result in re-imaging a patient. This re-imaging exposes the patient to additional ionizing radiation risk. This reexposure may, in and of itself, be a quality assurance occurrence (excessive patient exposure to ionizing radiation). The Quality Assurance Program requirement for consultative peer review leads to the third problem.

Access Limitations

A film image is available for viewing in only one place at one time to the number of persons who can crowd around a film alternator or lighted view box. Technologists can make a copy of the film, but copies are of inferior quality to the original and should not be used alone for diagnosis. This limitation means that copies are only useful as examples. Further, physicians may need to see the original films in a variety of functional areas such as outpatient clinics, operating rooms, post-operative care units, or intensive care units.

These three analog film limitations have remained virtually unchanged for the 95 years since Doctor Wilhelm Conrad Rontgen developed the use of ionizing radiation and film as a diagnostic tool. However, the recent advent of four enabling core technologies has made a new logistical approach to these problems feasible.

Four Core Technologies

The four technologies that give us the opportunity to improve the availability of medical imaging information are computerized radiography, economical storage, high-speed networks, and high-efficiency, high-resolution workstations.

While computerized radiography (CR) is the first core technology, a brief description of conventional film production helps to explain the new process. In conventional radiography, an x-ray unit, electronically tuned to focus the x-rays, bombards the object being x-rayed and a cassette containing film and a fluorescing screen beneath or behind the object. The screen fluoresces as a result of x-rays striking it, exposing the film sandwiched in the cassette against it. Developing the film produces a negative image of the object x-rayed. The different densities of the internal structures of the object imaged result in varying amounts of x-rays striking the screen, and the screen emits varying densities of light creating the film image. These varying shades of gray become the image from which physicians make their diagnosis.

Computerized Radiography

The CR system is similar. However, the imaging cassette receives only the photostimulable latent phosphor screen. There is no need for film or the fluorescing screen. Exposing the photostimulable latent phosphor screen to x-rays raises its electrons to a higher energy level. They retain this level of energy until they are scanned using a LASER and photomultiplier tube within the processing unit called a plate reader. This plate reader replaces the conventional water and chemical film processor. The plate reader retrieves the digital image by scanning the photostimulable latent phosphor screen. Exposing the screen to a halogen light releases the electrons to their normal state "resetting" the screen for reuse. These screens have been reprocessed as many as 90,000 times without a failure. At $800 per screen, that prices out to approximately $0.0018 per image compared to between $0.45 and $1.10 a sheet for film. The film prices do not include the cost of the film processor, processor chemicals, film disposal when they meet their retirement date, and film processor chemical disposal. The contaminated hypo solution is a hazardous waste requiring expensive disposal methods. Even taking into account the cost of the CR digital plate reader ($60,000), CR is a less expensive alternative. The creation of the processed digital images leads to the next technology and its impact.

Economical Storage

With the storage requirements mandated by the ACR, many medical treatement facilities (MTFs) must devote valuable facility space and lease expensive external space to store films. The shelving, floor space, labor to file and retrieve films, paper film jackets, and a myriad of other supply, equipment, and labor expenses add to the cost of the film. Further, decentralized storage and the problems with misplaced, lost, and stolen films result in reduced healthcare provider productivity while they wait for film images to arrive. In a survey in one large hospital, the probability of retrieving a film and its report from storage was 13 in 100. (1) A survey in another large facility revealed radiologists did not read or report on 22% of the films because other providers took films directly from the processors, or the images were lost or misplaced on their way from the film

processors to the radiologists for review. (1) With the cost of magnetic storage dropping as technological advances increase the amount of information storage on a given size magnetic disk, the short-term storage of digital images on magnetic media becomes an economical alternative.

For long-term archiving, the optical disk (CD-ROM) or optical streaming tape (CREO) has become an economical alternative. A 100-platter CD-ROM "jukebox" using 14-inch disks each containing 10.0 gigabytes of storage per disk (compressed 2:1) provides nearly a terabyte (1,000 gigabytes) of information in a space the size of an executive desk (approximately 72 inches by 42 inches or 21 square feet and approximately the height of a refrigerator). A single optical tape drive also holds a terabyte of information. The footprint of its equipment case is 24 inches x 29 inches (five square feet) and approximately the height of a refrigerator. A terabyte of storage capacity is sufficient to store 4 years of digital images generated by a 300- to 400-bed hospital, approximately 1,000,000 analog films. Currently, the equivalent in films would require a 5,000-square-foot room. High-density digital storage reduces the space required to 1% of that currently in-use. Being able to quickly locate and transmit digital images is as important as economical and secure storage of the images. High-speed networks allow us to quickly move large data sets electronically between the image acquisition device and the archive and from the archive to multiple display workstations.

High-Speed Networks

Some current high-speed networks are local (LAN), metropolitan (MAN), and wide area (WAN). LANs are intra-hospital networks; MANs are inter-facility networks (one building on a medical campus to another); and WANs (teleradiology networks) move images from one medical facility to another over long distances, city to city. Using T-1 data grade telephone lines (a low-speed network), ETHERNET (a medium-speed network), and Fiberoptic Distributed Data Interface (FDDI; a high speed network), LANs, MANs, and WANs rapidly transmit digital images and patient demographics within, among, and between medical facilities. High-speed image transmission provides the capability to centralize the image archive and decentralize the image acquisition and image display. Even with a geographically dispersed data network, the digital imaging system rapidly acquires and stores images and demographic data, and retrieves and accurately transmits such data to workstations. Advancement in workstation technology is the final improvement, making medical digital imaging a reality.

High Efficiency, High-Resolution Workstations

High-efficiency, high-resolution imaging workstations allow radiologists and other healthcare professionals to detect and document those anomalies, abnormalities, and subtle differences inside the human body using various types of imaging modalities. Imaging workstations must provide an image of sufficiently high resolution that the radiologists have a high degree of confidence in their ability to make an accurate diagnosis from the image displayed. Workstations must also allow radiologists to easily manipulate the images. Such manipulations must include pan (movement around the image screen), zoom (enlarging a portion of the screen much like using a magnifying glass), rotate (reorient the image in 90-degree increments), flip (turn the image upside down or left to right), window (electronically look through the entire digital data set of 12 bits even though only 8 bits can be displayed), level (select varying contrast levels dynamically), inverse video (reversing the negative image to a positive image), and on-screen mensuration (overlaying calibrated measuring templates). Finally, the images must appear on the screen in less than 2 seconds. In order for cathode ray tube (CRT) displays to meet the challenge of medical digital imaging, they have advanced to 1,024 x 1,280 pixel or 2,048 by 2,560 pixel resolution with six raster line pairs per millimeter on a single 21-inch viewable area diagonal screen. Conventional computer CRT resolution is 512 x 512 pixels. The high pixel densities provide radiologists an electronic digital image with the fine detail of film.

The workstation software permits the image manipulations the radiologist requires. Windowing and leveling permit the radiologist to enhance a poor quality original digital image by finding the optimum quality digital image within the full digital data set creating the image. Finally, the software transmits images from the archives to workstations at highly efficient speeds eliminating radiologist time wasted waiting for films. The software also permits providers at several workstations in several geographically separate areas to view the same digital image simultaneously making consultation easy and economical.

Digital imaging using high-technology systems meets the varying needs of nurses, attending physicians, radiologists, physician and nurse extenders, and radiologic technicians for diagnostic quality images when and where they need them. This improved access to images results in increased efficiency freeing healthcare providers to spend more time with patients. For logisticians, facility managers, architects and engineers, building maintenance staffs, and others, these high-technology systems improve space utilization, reduce the cost of constructing or leasing space for film storage, improve the efficiency of staff and patient flows, and reduce building maintenance costs.

MDIS System

The DOD medical service logistics community, recognizing the potential for this technology, is acquiring acquisition of digital imaging capability. The Services formed a joint technology evaluation group for MDIS System acquisition. The MDIS System is the DOD version of Digital Imaging Network/Picture Archiving and Communications System (DIN/PACS). The features making MDIS System technology attractive to DOD include its ability to solve problems as a radiologist force multiplier, enhanced capability in supporting a highly mobile beneficiary population, and logistical simplification of battlefield imaging resourcing.

Problem

Radiologist Shortages. There has been, and continues to be, a shortage of radiologists in DOD. DOD hires some radiologists from the local private sector healthcare community to work in its facilities or transports analog film images to a local private sector radiologist for reading. These solutions are expensive and contractually complex. Average cost per year DOD wide, within the 48 contiguous states for this type professional services, is $150,000 to $250,000 per radiologist, per facility.

Additionally, many smaller facilities ("country" hospitals and clinics) have insufficient radiology workload to justify a full-time radiologist. They rely on a DOD radiologist "circuit rider" or local private sector radiologist. The travel costs of the "circuit riders" are high. They visit on a limited schedule so imaging and diagnosis are delayed awaiting their visit. Further, emergency patients still require very expensive local private

sector radiology support. Finally, while the "circuit rider" is on the road, the "home" workload backs up.

Solution

Teleradiology As a Force Multiplier. We can electronically consolidate the imaging workload of "country" hospitals and clinics having insufficient imaging requirements to justify a full-time radiologist at the digital imaging hubs. For example, if we assume 60,000 radiographic images per year require one full-time radiologist to read and report, then three "country" facilities producing 20,000 images per year each, with electronic consolidation of their workloads at a hub, generate a requirement for one full-time radiologist. By creating digital imaging receiving hubs and transmitting spokes, using a transmission methodology called teleradiology, underserved areas can image patients, transmit images nearly instantaneously to the digital hubs, and quickly receive a telephone consultation from a radiologist. Nearly as quickly, the hub can electronically transmit to the spoke the radiologist's formal, written report for printing and filing in the patient's record. Teleradiology works as a force multiplier for radiology manpower assets.

Problem

Images and Beneficiaries. DOD has an inherently mobile population. On average, DOD active duty military healthcare beneficiaries move every three to five years. Additionally, there are frequent temporary trips to support contingency operations and training (Desert Shield, Just Cause, Hurricane Hugo disaster relief, etc.). Keeping medical diagnostic images with the mobile beneficiary so images are available immediately when needed is nearly impossible with analog film. As a result, beneficiaries are often re-imaged because of the unavailability of previous images.

Solution

Teleradiology As a Mobile Extender. A digital imaging network serves DOD's mobile beneficiaries and extensive DOD and private sector healthcare referral network. Teleradiology is inherently more efficient at adjusting to the beneficiary's relocation rather than the more expensive and less efficient methods currently in use (re-imaging, US Mail, etc.). Establishing digital imaging link-ups between DOD and private sector healthcare facilities permits easy transmission of diagnostic images to and from the referral facilities. An added benefit of the electronic networks with the private sector is enhanced quality of the radiologist residency programs. Electronic sharing of particularly useful and diagnostically interesting images from teaching files among multiple healthcare organizations improves the quality of resident training.

Problem

Battlefield Resourcing. Last in this discussion, but first in DOD importance, is battlefield applications. The weight and cube of film and chemicals prepositioned for wartime use are immense. Once a battlefield operation is underway, there is a continuing requirement to resupply film and chemicals. The film processors require water which, as Desert Shield/Storm operations demonstrate, can be a commodity in short supply on the battlefield. Recent wartime morbidity research shows there is an urgent need to locate CT scanners (an inherently digital imaging modality) in the battlefield environment. There are many types of projectiles whose presence in the body cannot be detected with conventional radiography. Only CT can effectively reveal the presence of Kevlar ™, nylon, plastics, synthetics, etc.

Solution

Battlefield Imaging. On the battlefield, the MDIS System eliminates the need for vast quantities of film and chemicals currently required for casualty care. Satellite, microwave, or land-lines can transmit images from the battlefield to a fixed healthcare facility. We can also store digital images on 3 1/2-inch optical disks at the moment of image acquisition and place them with the patient for transportation to the fixed healthcare facility. Using mini-optical disks is less weight, cube, and water intensive than analog films. The weight, cube, and electrical requirements of the digital plate reader are approximately those of the film processors. Overall, MDIS Systems provide logistical superiority to film.

DOD Leads the Way!

In the final analysis, healthcare will improve within DOD and the private sector with the proliferation of digital imaging technology. What's not known today is whether artificial intelligence (AI) incorporated into digital imaging can make some types of preliminary diagnoses. Research continues into the maximum acceptable image compression which reduces the amount of electronic storage required but retains a diagnostic quality image. It is clear we have yet to realize fully the limits on how much smaller, cheaper, and faster the technology can become.

Conclusion

The logistics community through advocacy for a systems approach to analyzing the benefits of new technologies, such as MDIS systems, can optimize direct healthcare benefits. This optimization occurs through combining the goals for quality healthcare set by patients, providers, and functional departments. These combined goals become the charter for medical logistics to look at each new technology and see not only the direct healthcare benefits but the improved logistics outcomes as well.

References

1. Goeringer, Fred. "Digital Medical Imaging/Teleradiology," a presentation at the Association of Military Surgeons of the United States, November 1990, Nashville, Tennessee.
2. Rose, Warren. "Logistics Management: Systems and Components," 1979, William C. Brown Company, Dubuque, Iowa, pp. 1-5.

Other Sources

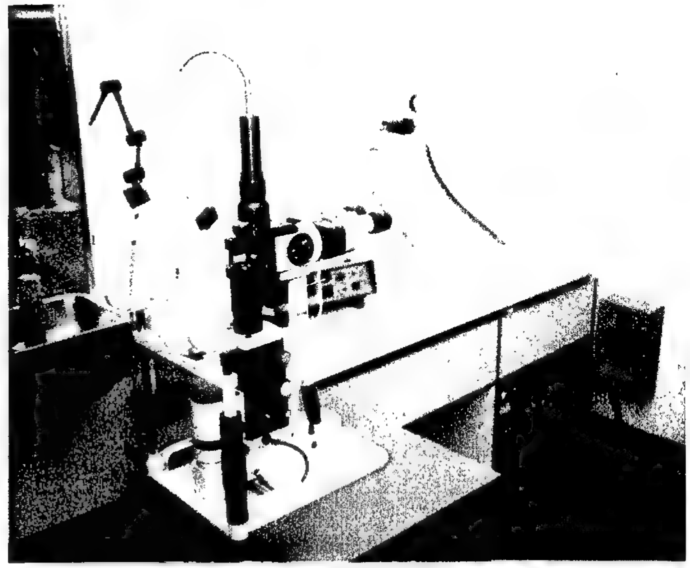
1. Benson, Harold R.; Mun, Seong K.; Elliott, Larry P. "Cost Analysis for the Development of Digital Imaging Networks," *Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE) - Medical Imaging II - 1988.*
2. Britt, Margaret O.; Ricca, Stephen P.; Rocca, Jeffrey J.; Sicherman, George L. "Optical Archive Organization and Strategies for the 1990s," *Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE) - Medical Imaging III - 1989.*
3. Fuhrman, Carl R.; Gur, David; Good, Barbara; Rockette, Howard; Cooperstein, Lawrence A.; Feist, John II. "Storage Phosphor Radiographs vs Conventional Films: Interpreters' Perceptions of Diagnostic Quality," *American Journal of Radiology,* Vol 150, May 1988, pp. 1011-1014.
4. Hedgecock, Marcus W.; Levitt, Tod S.; Smith, Suzy. "Calculating Storage Needs for an Optical Archive," *Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE) - Medical Imaging III - 1989.*

5. Huang, H. K.; Kangarloo, Hooshang; Cho, Paul S.; Taira, Ricky K.; Ho, Bruce K. T.; Chan, K. K. "Planning a Totally Digital Radiology Department," *Health Technology*, Vol 3, No 2, Summer 1989, pp. 31-39.
6. ter Har Romeny, Bart M.; Achterberg, A. J.; Binkhuysen, Barneveld F. H.; Andriessen, J. H.; Zuiderveld, K.J.; Raymakers, J.A.; van Waes, P.F.G.M.; Stut, W.J.J.; Scharnberg, B.; de Valk, J.P.J. "Procedures to Study the Impact of PACS on the Logistics Within a Diagnostic Imaging Department," *Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE) - Medical Imaging II - 1988.*

The original version of this article first appeared in the Silver Anniversary Annual International Logistics Symposium Proceedings of the Society of Logistics Engineers (1991).

Major Gelish is presently Chief, Medical Logistics Division, Office of the Command Surgeon, Headquarters, Pacific Air Forces, Hickam Air Force Base, Hawaii.

Ultrasonic Scanner.
(Photo courtesy GE Medical Systems)



Surgical Laser.
(Photo courtesy US Air Force)

Update

Since this article was originally published, the first fully digital healthcare facility in the DOD has come on-line. Madigan Army Medical Center, Fort Lewis, Washington, has been operational since March 1992. To date it has processed more than 100,000 images with the MDIS System. The System's uptime has exceeded 99%, and providers accept its use as routine business. Work to install additional MDIS Systems is underway at the USAF Medical Center, Wright-Patterson Air Force Base, Ohio, and Brooke Army Medical Center, Fort Sam Houston, Texas. A network of teleradiology hubs and spokes for the continental United States is currently being surveyed with implementations beginning in late calendar year 1993. In addition, the AKAMAI (Hawaiian for clever or the best of something) project proposes to digitally link the DOD healthcare facilities in the Pacific Theater. This theater extends from inside the Arctic Circle to the Equator and from the East Coast of Malaysia to the Hawaiian Islands. In early 1993 a digital imaging network will be put in place on the South Korean peninsula. Planning is also underway for a digital teleradiology linkup to Japan and Tripler Army Medical Center, Honolulu, Hawaii. DOD's commitment is strong and proliferation is moving forward with all deliberate speed.

Budgetary Outlook for the Military's Healthcare System

Robert F. Hale

Assistant Director
National Security Division
Congressional Budget Office
Washington DC 20515

The following Congressional Budget Office (CBO) Testimony was given by Mr Hale before the Subcommittee on Military Personnel and Compensation, Committee on Armed Services, US House of Representatives, on 7 April 1992. We thought it would be of value to our military readers since they are all affected by the healthcare budget.

I appreciate the opportunity to discuss the budgetary outlook for the military's healthcare system. In 1992, the Department of Defense (DOD) will spend more than $15 billion on healthcare, including more than $10 billion that is directly related to delivering peacetime medical services. The Administration's planned reductions in active-duty personnel should reduce the total number of beneficiaries in the military healthcare system by about 6% between now and 1997. Yet healthcare costs are still likely to rise. Indeed, the Congressional Budget Office projects that, under the Administration's plan for personnel cuts, spending on peacetime medical services would increase to $12 billion between 1992 and 1997—a five-year jump of 17%. Over that same period, the total budget for national defense would increase by only about 2.4% to about $291 billion.

DOD appears to be budgeting for increases in healthcare costs that are consistent with CBO's projections. But it may still be a challenge to accommodate military healthcare costs that rise about seven times faster than the overall budget.

If military healthcare costs must be held down, what are the options? It may be possible to contain costs through the Coordinated Care Program, which, in its reliance on managed care, is related to the CHAMPUS Reform Initiative and Catchment Area Management demonstrations. (CHAMPUS stands for the Civilian Health and Medical Program of the Uniformed Services.) Yet such programs also carry a risk of higher costs if improved services and benefits attract beneficiaries who are not now using the military healthcare system. Holding down costs may therefore require a broader restructuring of the healthcare system.

Background on the Healthcare Budget

DOD runs one of the nation's largest systems of healthcare. Military treatment facilities include 164 hospitals around the world—126 of them in the United States—and more than 500 separate outpatient clinics. In 1990, at least 52,000 civilian personnel and 157,000 active-duty military personnel worked directly for or in support of the system. In addition, DOD offers CHAMPUS, a traditional insurance plan that permits beneficiaries to receive care from civilian providers and pays the largest part of the bill.

In 1992, the total cost of military healthcare will amount to more than $15 billion. That includes the salaries of healthcare providers, both military and civilian, and all the day-to-day operating costs of the military's hospitals and clinics. Also included are costs of about $3.7 billion for the CHAMPUS program. In addition, the military healthcare budget funds a wide array of other activities: medical training courses, educational stipends for physicians and nurses, organic support for tactical units, epidemiological surveys, and basic research, to name but a few.

Last year saw a major change in how DOD organized the budget for its healthcare system. Consistent with a directive by the Deputy Secretary of Defense, the Assistant Secretary of Defense for Health Affairs now has authority over a consolidated "Defense Health Program." The program's budget totals $9.1 billion, most of which consists of operation and maintenance money covering such things as the salaries and benefits of civilian employees; supplies of x-ray film, food, drugs, and utilities in military treatment facilities; and reimbursements to civilian providers under the CHAMPUS program. The health program budget excludes the salaries and benefits of healthcare providers and support staff who are on active duty; those personnel remain under the budgetary purview of the military services.

In order to capture the cost trends that will be most affected by changes in numbers of beneficiaries, this testimony focuses on a different slice of the healthcare budget—namely, the costs directly associated with peacetime medical care. Those costs amount to more than $10 billion in 1992. The sum includes the salaries of all healthcare providers, both military and civilian, and the other costs of providing patient care in hospitals and clinics. A relatively small amount—$400 million to $500 million—pays for care supplied to active-duty personnel outside the system of direct care. The remaining $3.7 billion funds CHAMPUS.

It is important to focus on the total costs of peacetime healthcare. In recent years, Congress has tended to focus its concern on rising costs in CHAMPUS. Unlike spending inside military hospitals and clinics, spending under CHAMPUS constitutes a single, highly visible, and extremely elastic line item in the budget.

But CHAMPUS costs are inextricably linked to other parts of the healthcare budget. They soared during the last decade when military hospitals and clinics cut back on the access of nonactive-duty beneficiaries to healthcare services. Yet, in the 1990s, this trend could be reversed as more space becomes available in military facilities. Moreover, the line dividing CHAMPUS and direct care resources is becoming increasingly blurred because DOD now spends CHAMPUS money on alternative projects. Under one such project, the Partnership Program, civilian physicians sign agreements with DOD to treat CHAMPUS beneficiaries in a military treatment facility at CHAMPUS expense. In 1989, about 10% of CHAMPUS's outpatient visits were handled by Partnership physicians working in military clinics; by 1990, that proportion had climbed to 15%.

Base-Case Projections of Health Care Costs

To project the peacetime costs of medical care, CBO relied on DOD's own planning tool, the Resource Analysis and Planning System (RAPS). Feed the model assumptions about trends in the population of active-duty personnel and other beneficiaries, and about capacity in military treatment facilities, and the model projects future costs based on patterns of healthcare use in 1989 (the most recent fiscal year for which complete data are available).

Key Assumptions

In its base-case projection of costs, CBO followed the Administration's current personnel plans. Between now and 1997, those plans call for reducing DOD active-duty military personnel to a level of 1.6 million. The number of active-duty personnel in Europe, an important component of healthcare costs, is assumed to be reduced to a level of 150,000. A proportionate number of medical personnel and amount of resources are shifted from Europe to military treatment facilities in the United States. The base-case projection also assumes that the total capacity of military treatment facilities remains steady through 1997, an assumption consistent with Congressionally mandated limitations on reductions in medical personnel. Medical personnel and resources associated with the hospitals that are slated for closure (consistent with the recommendations of the Defense Base Closure and Realignment Commissions and subsequent Congressional action) are assumed to be transferred to other installations.

As for medical care prices, CBO's base-case projections assume that they will continue to rise sharply in the absence of broad-based reform of the US healthcare system. Based on past trends in the medical component of the consumer price index, CBO projects that medical prices will continue to increase at a rate of about 7% a year.

Projected Costs

Under these assumptions, peacetime healthcare costs in the military will increase in nominal terms by roughly $1.7 billion between 1992 and 1997, to about $12 billion. That rise represents growth averaging 3% to 4% a year—significantly lower than in the past; for the military healthcare budget as a whole, increases have averaged about 8% a year

during the past five years. The projected slowdown in the rate of growth in costs reflects expected declines in the beneficiary population and workload.

CBO's projections appear to be consistent with the planned growth in DOD's budget. The latest Future Years' Defense Plan calls for increases in the military health program that average about 4% a year between 1993 and 1997. Although the health program budget includes costs that are not directly related to the level of peacetime medical care, the trends are similar.

While growth might slow down, healthcare costs would still be increasing much faster than the total defense budget. Under the Administration's plan, the budget for national defense would grow from $283.8 billion in 1992 to $290.6 billion by 1997, an increase of 2.4%. Thus, the share of DOD's resources consumed by peacetime healthcare costs would rise under CBO's base case to just over 4%.

The Effect of Population Changes

The slowdown in the growth of the peacetime costs of military medical care reflects an overall decline in beneficiaries along with shifts in the composition of that population.

Overall Decline

The number of beneficiaries eligible to receive military healthcare now stands at about 8.7 million. That includes 2 million uniformed personnel, their roughly 2.6 million dependents, and 1.7 million retired military personnel and their 2.3 million dependents and survivors.

Under the Administration's current defense plan, the total eligible population will be 6% smaller in 1997 than in 1992. DOD active-duty end-strength will decline to 1.6 million, a decrease of about 13% from 1992. Active-duty dependents would presumably experience a parallel decline, to about 2.2 million. The population of retired military personnel and their dependents and survivors is projected to increase by a modest 2%, to a total of 4.1 million.

Decline in Beneficiaries Eligible for CHAMPUS

The 6% decline in the overall population masks substantial shifts among its various subgroups. One important subgroup—personnel eligible to use the CHAMPUS insurance program—would drop by 10% between 1992 and 1997. CHAMPUS eligibles include all dependents and retirees who are less than 65 years old. On reaching age 65, most nonactive-duty beneficiaries become eligible for Medicare and so lose their right to CHAMPUS. Only about 3% of retirees aged 65 or older continue under CHAMPUS.

The disproportionate decline of 10% in CHAMPUS eligibles reflects the expected fall in active-duty dependents as the size of the active-duty force is reduced. Added to that figure is an expected 7% drop in the number of retired military personnel and their dependents who are less than 65 years old.

Beneficiaries Eligible for Medicare Grow Sharply

In contrast to beneficiaries eligible for CHAMPUS, those eligible for Medicare will increase by about 28% between 1992 and 1997. The growth in beneficiaries eligible for Medicare puts upward pressure on military medical care costs because older people make greater use of healthcare resources.

However, this shift toward older beneficiaries may be less important to the military healthcare system than it would be for a civilian system. Although the use of healthcare services intensifies rapidly with age, DOD does not pay most of the bill for its older beneficiaries. On reaching age 65, most of them become eligible for Medicare and so lose their right to the CHAMPUS insurance program. Older beneficiaries are still eligible for care in military hospitals, but only if space is available. Otherwise they must rely on Medicare to help pay for their care at civilian facilities.

Thus, DOD can and does moderate the effects on its healthcare costs of an aging retired population by regulating access to military treatment facilities. Indeed, among retired military men who live within 40 miles of a military hospital, those aged 65 years or older are only about 30% more likely to be admitted to a hospital in the military healthcare system (directly or under CHAMPUS) than those who are less than 65. In the civilian healthcare sector, by contrast, men between the ages of 65 and 74 are more than three times as likely to be hospitalized as men who are less than 65.

Increased Space and the Demand for Care

As far as trends in DOD costs are concerned, the increase in beneficiaries eligible for Medicare is less important than the prospect of increased space becoming available in military treatment facilities. Ironically, an increase in space could put upward pressure on costs.

As the number of active-duty personnel and dependents declines, more space will become available. Some retired beneficiaries who now use CHAMPUS will instead be treated in military facilities. That shift should seemingly result in a reduction in the total cost of military medical care, since the cost of military treatment facilities will remain roughly unchanged while CHAMPUS costs fall. However, we know that when space opens up in military treatment facilities, the increase in demand for them is likely to be proportionally greater than any decrease in the use of the CHAMPUS insurance program.

The reasons for the disproportionate increase in demand are threefold. First, a considerable number of retired personnel are eligible to use the military healthcare system but choose not to do so. Rather than paying CHAMPUS deductibles and copayments, these "ghost" eligibles rely instead on their own financial resources, private health insurance, or the Medicare program. As free or inexpensive care in military treatment facilities becomes more readily available, some of the ghost eligibles may return to the military healthcare system, pushing up costs to DOD (although perhaps helping to lower costs for payers other than the military).

Second, payments by beneficiaries who visit physicians just a few times a year may not exceed the deductibles imposed by the CHAMPUS insurance program. Those beneficiaries are mostly retirees who do not currently file claims, so DOD incurs no costs. If the same people are now treated in military facilities, the change will increase costs to the government. Third, when care is inexpensive or free, as it is in the military treatment facilities, people use more of it.

To sum up these phenomena, DOD healthcare planners devised the so-called tradeoff factor, which is based on actual experience. Among retirees and their dependents, an increase of 2.2 visits to a military clinic results in a reduction of only one visit under CHAMPUS. That is, the tradeoff between care in military treatment facilities and CHAMPUS is about two to one.

CBO's projections rely on this tradeoff factor to estimate the effects on costs of shifting retirees from CHAMPUS to military treatment facilities. The result suggested by the tradeoff factor is not all bad: retirees would have better access to military medical facilities. But the phenomenon is one of the reasons that military medical care costs continue to rise despite the decline in the size of the active-duty population.

Policy Changes to Limit Growth in Healthcare Costs

Even though DOD appears to be budgeting for increases in healthcare costs similar in size to those CBO projects, accommodating those increases in a period when the overall budget is strictly constrained may still be difficult. Accommodation means that cuts in procurement and force structure will have to be larger than they would have been without the contrary trends. Growth in healthcare costs will also make it harder to fund other types of activities that may require additional resources, such as research and development or environmental cleanup. Moreover, these problems will worsen if there are significant cuts in the DOD budget beyond those now planned by the Administration.

If military healthcare costs must be held down, Congress could consider several possible policy changes:

- Limiting the access to the direct care system of beneficiaries eligible for Medicare.
- Reducing the number of medical personnel on active duty, thus promoting increased reliance on the civilian sector.
- Putting in place a program of managed care to lower the use of healthcare services and bring down the average cost of services provided in the civilian sector.

Decrease Access of Beneficiaries Eligible for Medicare

DOD generally has an incentive to hospitalize younger retirees in military treatment facilities rather than to pay their CHAMPUS insurance bills; it also has an incentive to refer retirees eligible for Medicare to the civilian sector and let Medicare pay their bills. How much might DOD save by restricting the access of older retirees to direct care?

To see, CBO modified the base-case scenario to hold constant—among all clinical areas—the share of the direct care workload for beneficiaries eligible for Medicare. Instead of accounting for 14% of direct care admissions in 1997, as they do in the base-case projection, senior citizens are held to their current level of about 10%.

The resulting projections suggest only a modest effect from such a policy. Compared with the base-case projection of $12 billion, the costs of providing peacetime medical services would decline to $11.6 billion, a difference of only 3%. About one-third of the projected saving comes from reductions in CHAMPUS costs. These reductions occur as beneficiaries under 65, who would have otherwise used CHAMPUS benefits, take advantage of spaces in military treatment facilities freed up by the reduction in patients who are eligible for Medicare. The remaining saving comes from reduced costs in military treatment facilities.

One reason for the small saving is that an across-the-board reduction in older patients would free staff and space not necessarily relevant to a younger population. Four clinical areas account for 70% of the patients eligible for Medicare who are admitted to military hospitals: internal medicine (36%), general surgery (17%), cardiology (9%), and urology (8%). Yet these areas are not the ones primarily required by the younger beneficiaries who would take up the slack space in military treatment facilities. Indeed, these four areas account for only about one-quarter of the patients who are currently admitted to civilian hospitals under CHAMPUS.

DOD could save more money if it referred most or all of its patients eligible for Medicare to civilian hospitals and reorganized its hospitals and medical staff to provide care more appropriate to younger patients. But reorganizing hospitals to meet the needs of younger patients—which would mean emphasizing pediatrics, psychiatry, and obstetrics—might leave DOD medical personnel less well prepared to meet wartime needs. Moreover, military treatment facilities, especially the large teaching hospitals, need a certain flow of elderly patients and their complicated problems to burnish and maintain the skills of military healthcare providers. Thus, large-scale shifting of beneficiaries eligible for Medicare to the civilian sector does not appear to be a promising way to hold down military healthcare costs.

Decrease Medical Personnel on Active Duty

Congress has expressed a desire to avoid reductions in medical personnel during the overall drawdown of DOD personnel. Thus, CBO's base-case projection of costs assumed no cuts in medical personnel. Congress has, however, authorized two conditions for making reductions: personnel being reduced must exceed the current and projected needs of the military departments, and the reduction must not result in an increase in the cost of healthcare services provided under CHAMPUS.

Following those guidelines, the services have apparently decided to make modest cuts in medical end-strengths. In last year's five-year plan for medical staffing, all three services proposed reducing authorized spaces for medical personnel assigned to the United States between 1991 and 1995. The Navy would cut physicians and nurses by about 4% and enlisted support staff by 1%. The Air Force would cut physicians by less than 1 percent and nurses and various military support staff by 8%. Finally, the Army tentatively proposed cutting physicians by 4%, nurses by 9%, and various active-duty support positions by at least 16%.

How might such end-strength reductions affect healthcare costs? Assuming proportionality between staffing and capacity, CBO modified the base-case scenario to translate the aforementioned reductions in personnel to reduced capacity in military treatment facilities. As a result, the RAPS model projects a 4% swing of patients from military treatment facilities to CHAMPUS, but no significant change in overall costs— indeed, a difference of less than $100 million.

Why so little change? It generally costs more to hospitalize an individual patient under CHAMPUS than in a military hospital. Thus, the shift of patients to CHAMPUS would itself tend to increase costs. But the tradeoff factor discussed earlier in this testimony works in the opposite direction and results in little overall change in costs. Among retirees, who would be most affected by a reduction in the capacity of military treatment facilities, the tradeoff factor suggests that as staffing is reduced, the reduction in admissions to military facilities would be about twice as large as the increase in CHAMPUS admissions. Thus, there would be a net decrease in treatment accorded to retirees, which holds down costs.

Establish Managed Care

Putting in place a system of managed care represents a third option for holding down costs. Broadly defined, managed care is a strategy for controlling the use and quality of healthcare services, as well as costs. It tries to influence decisions that heavily influence costs, such as when care is given, how much is given, where it is provided, and how long treatment continues. To date, the most successful practitioners of managed care have been group model health maintenance organizations (HMOs); they own their own hospitals, require primary care gatekeepers, and rigorously review hospital use. To the extent that DOD emulates the practices of group model HMOs, the option for managed care offers a demonstrable potential for savings.

Since 1988, DOD has put various aspects of managed care to the test in the CHAMPUS Reform Initiative in California and Hawaii and in the Catchment Area Management (CAM) demonstrations in five sites around the country. And now DOD is poised to begin the Coordinated Care Program, which by the end of 1994 is supposed to have in-place a system of managed care on all military treatment facilities in the continental United States.

Will coordinated care hold down future costs to the Department of Defense? The Coordinated Care Program resembles CAM in many details, and CBO has recently reviewed the early results of those demonstrations.* Although it is too soon to reach a final judgment about the cost-effectiveness of CAM, CBO's earlier review of the demonstrations points to some revealing trends.

CAM gives local managers control over most or all of the healthcare resources in a particular geographical area and challenges the managers to provide good care while also holding down costs. The CAM sites generally have tried to save money in two ways: by negotiating discounts with civilian providers and by making greater use of military treatment facilities. In setting up networks of private physicians, local medical commanders were able to negotiate discounts—typically ranging between 10% and 30% against prevailing CHAMPUS charges. To increase the use of military treatment facilities, all the CAM sites have hired civilian physicians to work inside military facilities under the partnership program. Moreover, some of the sites require that primary care physicians always refer patients to military specialists rather than civilian specialists.

Trends in the civilian healthcare system might exacerbate the problem. Surveys show that businesses are obliging their employees to carry a larger share of the healthcare burden through increased premiums, higher deductibles, and copayments. Rapidly rising healthcare costs may force more and more small businesses to eschew health insurance for employees altogether. Retired families, which make up the largest part of the military's ghost population, will be affected by these civilian trends. As employers diminish the appeal or availability of private health insurance, increasing numbers of ghosts may appear in the military healthcare system.

Broader Restructuring

Even if the Coordinated Care Program improves the efficiency of military healthcare, increased demand for care could escalate the upward rise in costs. Add to this the growth of expensive, new medical technologies and costs could rise still faster.

Should that happen, the only remaining remedy may be a fundamental restructuring of military healthcare benefits. Such an

* Congressional Budget Office, "Managed Care in the Military: The Catchment Management Demonstrations," CBO Papers (September 1991).

MORE →

READER EXCHANGE

Combat Support Doctrine

I have been one of the opponents of the "Combat Support Doctrine" which failed to recognize its logistics base with even one use of the word "logistics." I knew the politics behind the choice of terms and it sickened me. My comments to the major author met only such retorts as "Well, it is better to have something than nothing!" and that sickened me even more. I strongly agree the need is for rework of our logistics doctrine now and a return to "logistics" rather than these misleading alternates. The Gulf War, and the extreme budget/manpower reductions, make rework of logistics doctrine absolutely essential. But, it should be accomplished by people with experience rather than by those who have Gulf War experience but little else to offer.

I am concerned about the fact so few people truly understand what military logistics is all about. We have a good number of people who are competent in their specialties (supply, maintenance, or whatever) but know/understand little about all the other aspects of logistics. Rarely can you find anyone who recognizes people as a major element of logistics. I doubt you could find 5 out of 100 who would acknowledge recruiting, technical training, or education as elements of military logistics; yet, we have nothing if we have no people. Certainly, "creating and sustaining military capability" cannot be accomplished without people. The result of people, of course, is the extensive support requirements which constitute a major portion of the overall logistics effort—mail, food, medicine, pay, recreation, housing, clothing, weaponry, protective items, and so on. I realize I am running on, but I am trying to make the point that logistics is far more than merely maintenance, supply, transportation, procurement, and planning. Yet, we rarely recognize that.

Doctrine is, or should be, extremely important to the military person. It should be mandatory reading for everyone, and everyone should be examined on it periodically. It should be part of the enlisted promotion examinations, and it should be an extensive part of all professional military education (PME). People should understand their applicable doctrine because it ought to be the basis for all their professional actions and agreements. But, I have come across only a minimal number who know of logistics doctrine and few who have read or understand it. Why? Because they don't know what doctrine is supposed to be and, therefore, think that it is some form of esoteric military gobbledegook—probably dry, dull, and uninteresting.

So, I am suggesting that you can do the Air Force, and logistics, a lot of good if you obtain and publish some articles, at least one good one, describing in simple statements and simple words just what doctrine is supposed to be, what it is supposed to do, how it is supposed to be used, why it is important to the individual military person, how it should be involved in planning, and how it should lead thinking. Further, the articles must provide some positive ideas and examples about what is and what isn't doctrine.

PEOPLE DO NOT UNDERSTAND DOCTRINE! The mere fact the AF publishes a logistics doctrine manual in no way assures understanding or acceptance. We need to change that! We need to have people clamoring for doctrine and doctrinal actions in their daily work efforts and their planning for potential defense efforts.

Jerome G. Peppers
Professor Emeritus
Air Force Institute of Technology

Continued from page 29

effort would raise some tough questions. Should all beneficiaries, especially retirees and their dependents, be allowed unlimited access to military treatment facilities at little or no cost? Regardless of where care is rendered, should military beneficiaries carry a larger share of the cost burden through increased deductibles and copayments, or through health insurance premiums? Can DOD identify and limit recourse to high-cost and low-benefit tests or procedures? Congress may have some answers to these questions when DOD completes its comprehensive study of the military medical care system required by last year's National Defense Authorization Act.

In mandating the comprehensive study, Congress underscored that more is at stake than the cost of peacetime medical services. First and foremost, the military healthcare system exists to support the armed forces in time of war. As DOD transforms the structure of the armed forces to accommodate reduced threats to US security, it may also alter its approach to wartime healthcare. The restructuring might involve fewer active-duty medical personnel, fewer hospitals and clinics, and fewer programs of graduate medical education. Such changes would undoubtedly intensify the need to restructure peacetime healthcare benefits.

Conclusion

The coming drawdown in active-duty personnel will help to moderate future increases in healthcare expenses. But under current policies, those costs are likely to continue to rise much faster than the overall DOD budget. Although further cost reductions may be possible from the Coordinated Care Program, savings will be assured only if military medical managers emulate the managed care practices of their civilian HMO counterparts. Even then, costs may accelerate if the program attracts ghost beneficiaries back into the military healthcare system. Substantial savings may ultimately require a broader restructuring of the system.

Logistics Professional Development

Updates on the Voluntary Assignment System

The officer voluntary assignment system is alive and well, but it has gone through some growing pains since implementation in August 1991. Most of the "kinks" in the system have now been worked out, and access to the Electronic Bulletin Board (EBB) has been steadily improving over time. Some of the latest changes include:

a. *The timing in which an officer can de-volunteer for a position.* Previously, the "need volunteer by" date only represented the time at which we stopped taking new names for a position. If officers wanted to remove their names from a volunteer list after the closeout date, they could, as long as they were not the number one selectee, or we could find other officers to take their place in the same time frame (even after they had a firm assignment). However, over time, we found this flexibility made the assignment system less equitable. Consequently, we established a new rule for working officer assignments. Now, we do not allow officers to de-volunteer for a position after the "need volunteer by" date has passed. There are a number of reasons why this makes more sense. For instance, once the position closes on the EBB, we offer the top officers to the gaining MAJCOMs. If they are accepted, we have to perform many time-consuming tasks to accommodate that selection. Therefore, we now tell all officers who volunteer for a position that they must call and "de-volunteer" before the closeout date if they decide they may not want the position.

b. *Assignment of intermediate service school/senior service school (ISS/SSS) graduates out of school.* Officers who attend professional military education (PME) in residence will have preference for numerous joint and key staff positions upon graduation. At present, most of the field grade officers will be assigned to joint duty positions (finalized between October 1992 and January 1993) due to the big demand for these graduates. For example, transportation has 19 joint duty positions that need to be filled this year, but we only have 10 officers in school. Many other Air Force specialty codes (AFSCs) have the same problem—not enough joint specialty officers to go around. Officers need to keep in mind that the promotion rate for joint duty should be equal to or better than the Air Staff average. Thus, they stand as good a chance of being promoted in the joint position as they do in a squadron commander position after graduation. They then can go to a commander billet or be eligible for many other challenging and interesting jobs.

c. *Movement of nonvolunteer officers with 15 years of service.* The number of volunteers for advertised positions has been fairly low for the first few months. This had caused many positions to close out without volunteers. If the job has been vacant for a while, or if it is considered a critical position, the MAJCOM Director of Assignments may request it be filled with a nonvolunteer. When this happens, we pull the names of the top five, most vulnerable available officers from a computer-generated list and inform their losing commands of their vulnerability for a nonvoluntary assignment. These rosters only include officers with over 15 years of military service because that is when they are considered career officers. Vulnerable officers are then contacted and advised they have five days to volunteer if they desire. At the same time, the owning MAJCOM is notified that the officers are being considered for a nonvoluntary assignment. Many times, one of the contacted officers will call to volunteer for the job, making it unnecessary to put a nonvolunteer on assignment. If no one volunteers, the top eligible officer will be put on assignment at the end of the five days.

These are a few of the important changes that have been made in the assignment system in the past few months. The voluntary assignment system can affect an officer's future, so it is important to stay abreast of any changes in the system. A detailed description of this system can be found in the new *Officer Volunteer Assignment System Reference Guide* dated July 1992. If you have not received a copy of this guide, go to your nearest Military Personnel Flight Office (formerly Consolidated Base Personnel Office).

(Major Starkey, AFMPC/DPMRSA4, 487-6417)

AFIT *The Doorway to Logistics Success*

Evolutionary Changes at AFIT

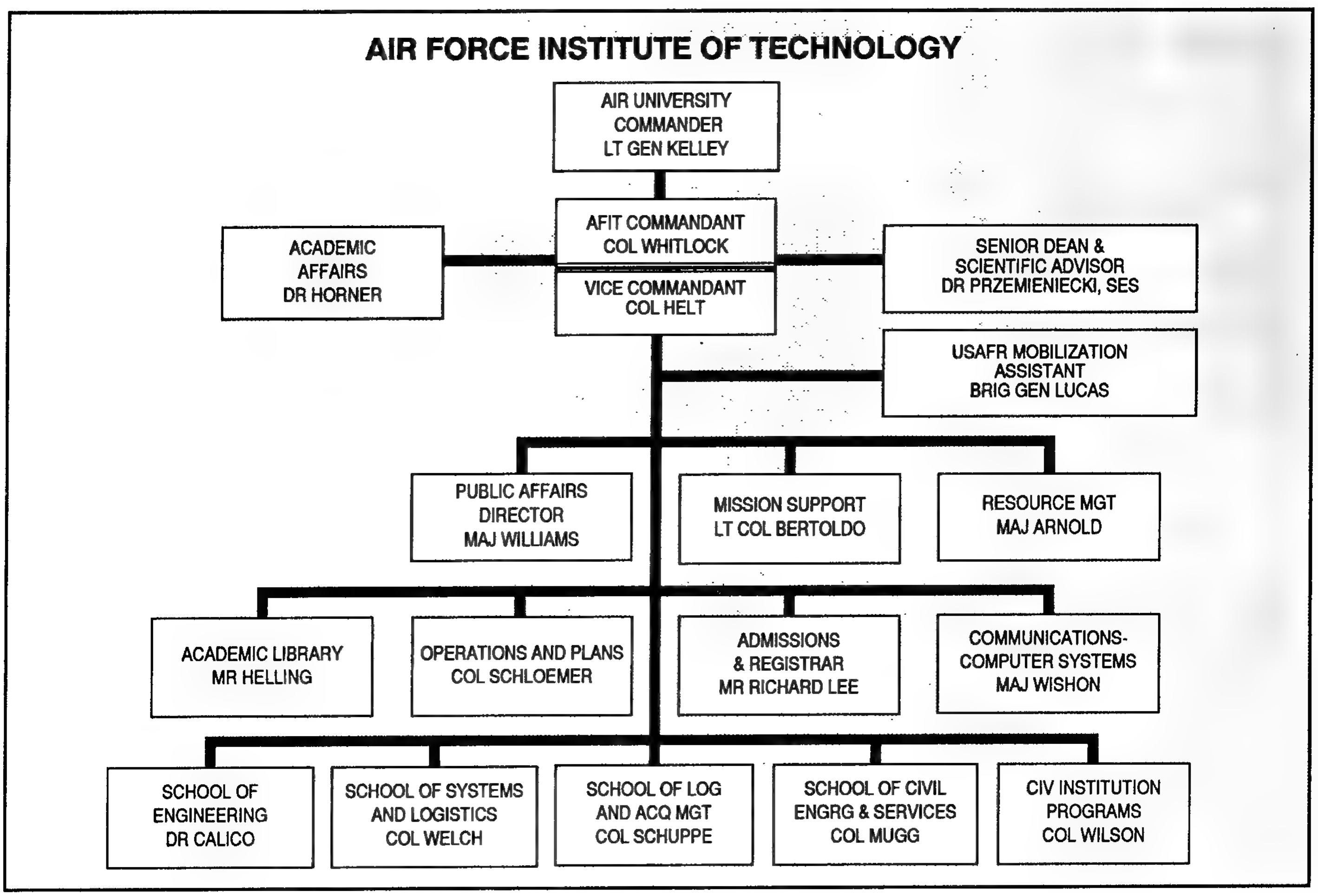
A recent internal organizational restructuring has resulted in a major change at the Air Force Institute of Technology (AFIT), Wright-Patterson AFB, Ohio. The School of Systems and Logistics, which has offered professional continuing education (PCE) courses since 1955 and courses in residence leading to a graduate management degree since 1963, has been separated into two schools.

The newly created AFIT School of Logistics and Acquisition Management (AFIT/LA) is responsible for graduate management education. Colonel Thomas Schuppe is the School's Dean and Lieutenant Colonel Phillip Miller is the Associate Dean. AFIT/LA has three departments: Graduate Logistics Management (AFIT/LAL), Graduate Management Systems (AFIT/LAR), and Graduate Systems Management (AFIT/LAS).

The School of Systems and Logistics (AFIT/LS) is now responsible for professional continuing education exclusively. Colonel Paul Welch is the school's Dean and Dr Richard Murphy is the Associate Dean. AFIT/LS has six departments: Government Contract Law (AFIT/LSL), Logistics Management (AFIT/LSM), Contracting Management (AFIT/LSP), Quantitative Management (AFIT/LSQ), Software Engineering (AFIT/LSS), and System Acquisition Management (AFIT/LSY).

In addition to the separation of graduate and professional continuing education, certain staff directorates have been redesignated as providing either academic support of student operations or mission support. Student administration and operations are handled by AFIT/LAA (Lieutenant Colonel John Shishoff) and AFIT/LSA (Mr Jon Graham) for graduate and PCE courses, respectively.

Since the changes are primarily transparent to its customers, the Institute will continue to offer premier education to all customers in all AFIT schools.



SCHOOL OF LOGISTICS AND ACQUISITION MANAGEMENT (AFIT/LA)

Colonel Thomas Schuppe Dean	AFIT/LA WPAFB OH 45433-6583 DSN: 785-2150 Commercial: (513) 255-2150

DEPARTMENT	NAME	TELEPHONE
Graduate Logistics Management (AFIT/LAL)	Lt Col David Diener	DSN: 785-5023 COM: (513) 255-5023
Graduate Management Systems (AFIT/LAR)	Dr Robert Weaver	DSN: 785-2554 COM: (513) 255-2554
Graduate Systems Management (AFIT/LAS)	Lt Col Michael Heberling	DSN: 785-4845 COM: (513) 255-4845

SCHOOL OF SYSTEMS AND LOGISTICS (AFIT/LS)

Colonel Paul Welch Dean	AFIT/LSM WPAFB OH 45433-6583 DSN: 785-5361 Commercial: (513) 255-5361

DEPARTMENT	NAME	TELEPHONE
Government Contract Law (AFIT/LSL)	Dr Robert Wehrle-Einhorn	DSN: 785-3809 COM: (513) 255-3809
Logistics Management (AFIT/LSM)	Dr Dennis Campbell	DSN: 785-4149 COM: (513) 255-4149
Contracting Management (AFIT/LSP)	Mr Dyke McCarty	DSN: 785-3944 COM: (513) 255-3944
Quantitative Management (AFIT/LSQ)	Dr Roland Kankey	DSN: 785-6280 COM: (513) 255-6280
Software Engineering (AFIT/LSS)	Maj William Rogers	DSN: 785-4500 COM: (513) 255-4500
System Acquisition Management (AFIT/LSY)	Mr Richard Andrews	DSN: 785-2632 COM: (513) 255-2632

A Proposed Approach for the Integrated Use of Stand-Alone Logistics Software Tools

Dinesh Verma
Alberto Sols

Background

The objectives of an integrated logistic support strategy cannot be achieved without the timely and concurrent consideration of logistics disciplines throughout the system life cycle. Given that design in the modern world is conducted predominantly in a computer-aided environment, numerous (commercial) computer-based logistics models and tools have been developed to aid the system design process. Unfortunately, most commercially available computer-based tools operate on a stand-alone basis. The purpose of this paper is to propose a methodology and make a case for integrating stand-alone logistics computer models and tools beginning in the nascent stages of the system design process.

Introduction

An integrated computer-based logistics analysis environment can contribute significantly towards the development of an effective, efficient, and easily supportable system. Moreover, this scenario is in concert with the philosophies of concurrent engineering and system life-cycle engineering. (2) Lack of integration between most currently available tools forces the system designer to manually perform the required data exports and imports. Given the relatively low amount of information available during the early design stages, the relevant data can be communicated between various logistics analyses with a reasonable amount of effort. A single consistent database further ensures effective utilization of these tools to perform predictions and estimations. Moreover, the opportunity to conduct trade-offs and sensitivity analyses in real time more than justifies the effort involved in persisting with an integrated approach.

The methodology proposed in this paper is the result of some of the research activities being conducted currently in the Systems Engineering Design Laboratory at Virginia Tech. The overall objective of this research is to interact with selected commercial software vendors and progress towards an increased integration between computer-based logistics models and tools. (3,6) The Systems Engineering Design Laboratory was organized within the Industrial and Systems Engineering Department at Virginia Tech in 1990 and has served as a catalyst for further adapting selected computer-based models and tools for the purpose of education and training. (4,5)

The Traditional Approach

Computer-based tools have traditionally been used to facilitate the prediction and estimation of various relevant system parameters; for example, reliability, maintainability, and life-cycle cost. Unfortunately, influenced by the existing computer tools environment, the corresponding analyses have remained stand-alone as well. The communication and feedback essential to such analyses are absent; this prevents the system designer from exploiting these models and tools to their full potential. Figure 1 depicts this traditional and non-integrated approach to logistics support analysis.

Refinement of the system configuration, from a supportability perspective during the early design and development phases, is

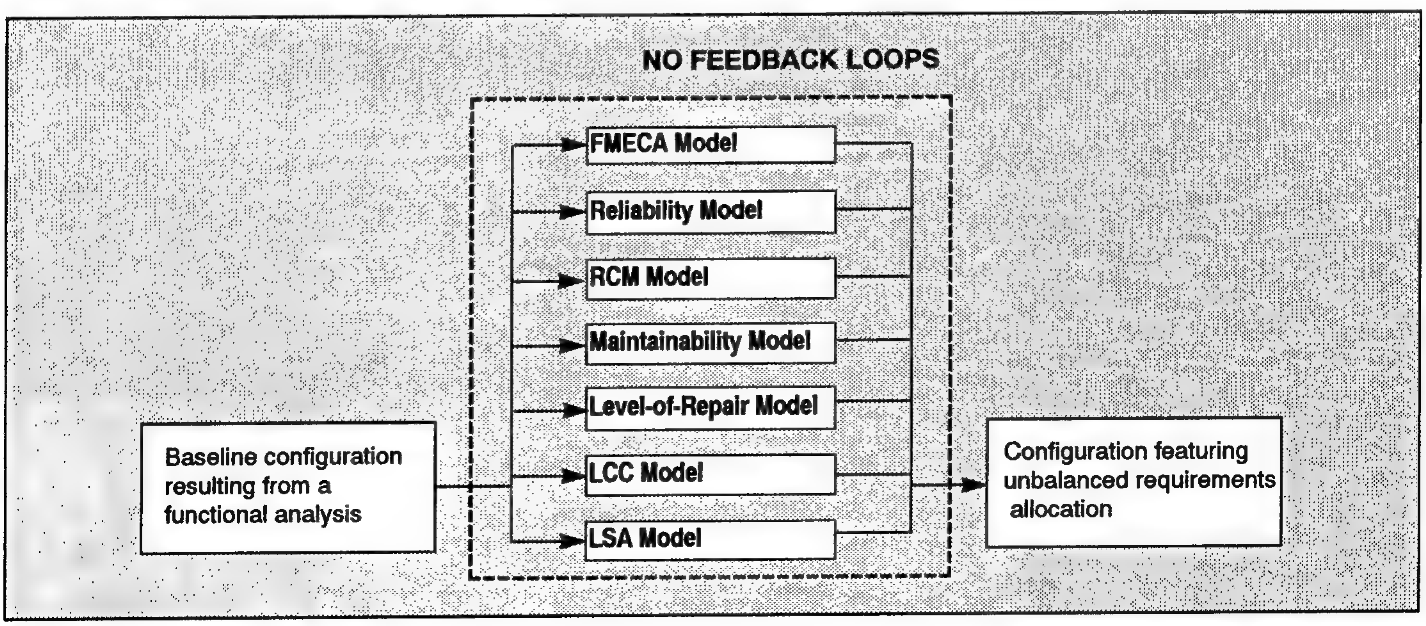


Figure 1. Traditional logistics analysis approach.

awkward and inefficient in an environment dominated by isolated logistics-related analyses. This could result in the development of a system/product that is not cost-effective, since it may feature expensive and avoidable incompatibilities between the performance/operation and support/maintenance functions.

A Preferred System Design Approach

Concurrent engineering and system life-cycle engineering involve the timely and simultaneous, rather than sequential, consideration of numerous design, production/construction, operations, and support related system parameters (Figure 2). It is imperative that these "downstream" issues influence system design from the onset. This exercise facilitates the design and development of a system/product with a proper balance among the often conflicting requirements and design objectives (pertaining to both performance and support).

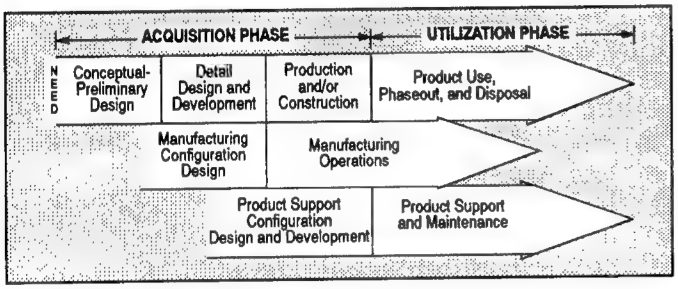


Figure 2. Concurrency in design. (2)

The system design process evolves from a market/need analysis. After the initial feasibility study, the system requirements, constraints, and the associated design criteria are defined based on the need identified. The system requirements should address both the prime mission and the necessary sustaining support. Thereafter, relevant system operational, test, production, and support functions are identified and the functional analysis completed. A completed functional analysis results in the initial synthesis of the system configuration. The appropriate system requirements are now allocated down to the subsystem, module, unit, and lower levels in this system configuration/structure. (1,2) The refinement of this initial configuration and allocation is done by subjecting the numerous feasible and alternative approaches to a structured systems analysis process. The output from this analysis is the preferred system configuration. In order to ensure convergence to this preferred configuration, the analysis process must feature the necessary communication and feedback functions. Further, trade-offs and sensitivity analyses are performed to gauge and ensure robustness of the final configuration. Effective "what-if" studies can be conducted if the underlying analyses are integrated.

Proposed Methodology

The Systems Engineering Design Laboratory is overcoming the current lack of integration between most available computer-based logistics tools through a process of linking their inputs and outputs. The result is an approach in which the different analyses are conducted in a concurrent manner during the system design phase. The resulting process is truly iterative, with appropriate feedback loops originating at each individual analysis. The adopted approach is shown in Figure 3.

As a first step, reliability predictions are accomplished concurrently with a failure modes, effects, and criticality analysis (FMECA). The FMECA accepts reliability estimates

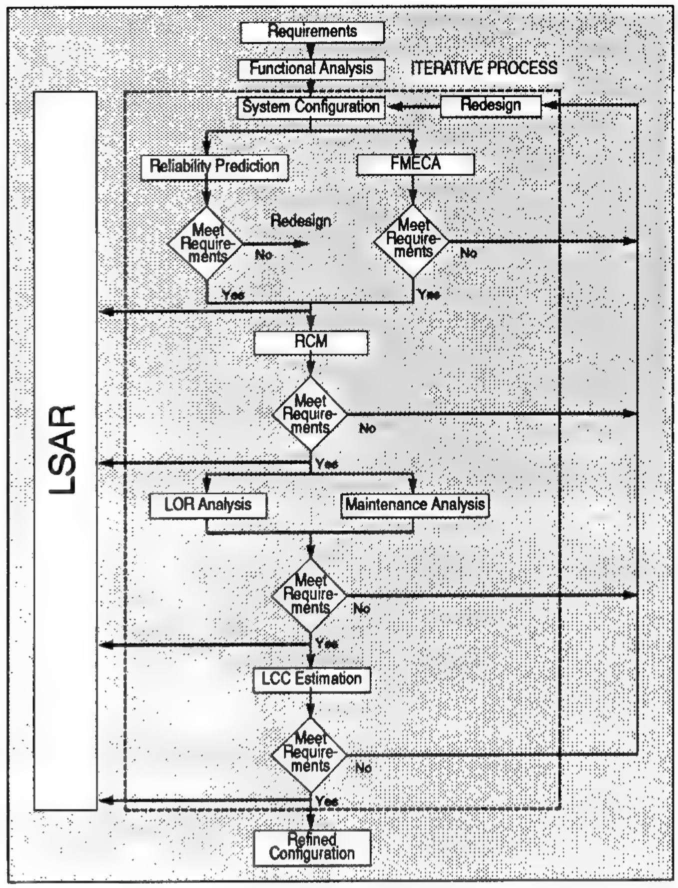


Figure 3. Integrated analysis approach using stand-alone computer-based logistics models and tools.

as inputs from the reliability prediction and analysis tool. A system redesign is deemed necessary if the predicted reliability fails to meet the system requirements, or if unacceptable failure modes/effects are identified during the FMECA. After the system design satisfies the requirements of this step, the process continues with the performance of a reliability-centered maintenance (RCM) analysis.

Each of the potential system failure modes identified through the FMECA is subjected to the RCM decision logic. The objective of this analysis is to customize a cost-effective and efficient preventive maintenance program for the system being designed. The output from this analysis consists of specific preventive maintenance tasks, their frequency, and the relevant support requirements. A sound and well-thought-out preventive maintenance program can help maximize the inherent reliability/availability of the system.

Once the RCM analysis is completed, the next step is to conduct a level of repair (LOR) analysis along with a maintainability prediction. Those two analyses should be performed concurrently. The maintainability predictions help ascertain whether the current system configuration meets the system maintainability requirements, while the LOR analysis facilitates the determination of the most cost-effective repair policy for every relevant system element. Concurrency between these two analyses is required, since changes in the repair policy for an element (for example, changing the repair policy from repair by replacement to on-site maintenance) will have a significant impact not only on the maintainability of the specific element but also on the overall system. If the system configuration does not meet the maintainability requirements, or if the recommended

FROM \ TO	LSAR	LCC	LORA	MAINTAINABILITY	RCM	FMECA	RELIABILITY
RELIABILITY	MTBFs and Failure Rates	MTBFs and Failure Rates	MTBFs and Failure Rates	MTBFs and Failure Rates	MTBFs and Failure Rates	Failure Rates	
FMECA	Failure Modes, Effects, and Criticality			Failure Modes and Their Effects	Failure Modes, Effects, and Criticality		
RCM	Summary of Maintenance Tasks		Types of Maintenance Tasks	Maintenance Tasks			
MAINTAINABILITY	Detail Description of System Maintenance Tasks	MTTRs and Required Skill Levels and Tools	MTTRs and Required Skill Levels and Tools				
LORA	Repair Policies	Repair Policies Costs					
LCC	Costs						

Table 1. Proposed information exchange and communication.

repair policy is not considered acceptable, then the system will have to be redesigned as necessary.

Finally, a life-cycle cost (LCC) analysis is performed to assess the overall cost-effectiveness of the system.

Each analysis performed provides a corresponding input to the logistics support analysis record (LSAR). The iterative nature of the analyses ensures the required concurrency to achieve the objectives of an integrated logistics support analysis strategy. The data that may need to be communicated across and between various analyses is made explicit in Table 1. Efforts expended in performing these interchanges of information among analyses are justified given the significance of the benefits obtained. This claim is validated by the experience gained through research conducted in the Systems Engineering Design Laboratory. (3) It is important to mention that numerous commercial tools are available for each analysis that may have to be performed during the system design process; for example, FMECA; reliability allocation and prediction; and maintainability allocation and prediction. The approach outlined in this paper is independent of the tools finally selected. More often than not, tools developed by the same vendor are likely to have a better interface between each other as compared to tools developed by different software developers.

A Plea to Logistics Software Developers

The system design and logistics communities have long since felt the need for an integrated design synthesis, analysis, and evaluation workstation. Software developers need to respond to this need. The development of a truly integrated logistics analysis environment will significantly contribute to the increased robustness of the system/product ultimately deployed in the field. Such a workstation will facilitate the necessary consideration of various "downstream" logistics issues during the early design phases. The logistics analysis tools need to be compatible with a standard database structure. Information used and generated by these analyses could then be stored in a standard format. This would enable data exchange both within a project and among cooperating organizations, in accordance with the current trends relative to the computer-aided acquisition and logistics support (CALS) initiative.

References

(1) Blanchard, B. S. *Logistics Engineering and Management*, 3rd Edition, Prentice-Hall, Inc., Englewood Cliffs NJ, 1992.

(2) Blanchard and Fabrycky, W. J. *Systems Engineering and Analysis*, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs NJ, 1990.

(3) Field, D. J. *Systems Engineering Tools Assessment - An Independent Study in Systems Engineering*, College of Engineering, VPI&SU, 1991.

(4) Verma, D., and Blanchard. "Logistics Engineering Education: A Case Study Involving Course Development," *Logistics Spectrum*, Journal of the Society of Logistics Engineers, Summer 1992.

(5) Verma, Sols, A., Fabrycky, and Blanchard. *Computer-Based Courseware for Systems Engineering and Training*, Proceedings, National Council of Systems Engineering, Seattle, Washington, July 1992.

(6) Verma and Sols. *Derivation of System Level Requirements Through the Integration of Computer-Based Logistics Tools*, Proceedings, SOLE Symposium, Indianapolis IN, August 1992.

Dinesh Verma is Graduate Project Assistant, Systems Engineering Design Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Alberto Sols worked in the Systems Engineering Design Laboratory, but is now employed in Madrid, Spain.

CURRENT RESEARCH

Air Force Materiel Command (AFMC) Management Sciences Study Program

The AFMC Directorate of Management Sciences (AFMC/XPS) is responsible for developing, managing, and executing the Air Force Materiel Command's management sciences program. The Directorate is comprised of two Divisions: the Analytic Applications Division (XPSA) and the Concept Development Division (XPSC). We conduct and sponsor studies and research of significant materiel issues. We use, modify, and develop new or improved methods, models, and tools to manage materiel resources. Our goal is to quantify the relationships between alternative resources and resultant aircraft availability and sustainability so that AFMC can prioritize and justify its investments in those resources. We work toward this goal by performing studies for customers in the headquarters and by pursuing a few internally developed projects which have significant potential for providing valuable insights into these relationships. In the past we have focused on four major areas: Distribution and Repair In Variable Environments (DRIVE), Weapon System Management Information System (WSMIS) enhancements, Engine Pipeline Studies, and the cost and responsiveness implications of a number of specific alternatives designed to reduce materiel costs. We are continuing work in these areas. In addition we have added seven new efforts: Aircraft Availability Model (AAM) Excursions, Two Level Maintenance Analysis Support (CORONET DEUCE), Readiness Based Initial Requirements Determination (RBIRD), support for development and use of the Logistics Assessment Models (LAMs), Requirements Interface Process Improvement Team (RIPIT), and Joint Logistics Systems Center (JLSC) Support. We work closely with our customers as we design and perform studies to ensure we have a healthy balance between the rigorous application of operations research techniques and practical, "implementable" solutions.

The following projects are representative of the work in which we are involved:

Distribution and Repair In Variable Environments (DRIVE): Our recent and planned efforts support DRIVE implementation in the Air Force. We also foresee significant activity in support of the Joint Logistics System Center DRIVE near-term initiatives. In the past year, we have improved the DRIVE model non-flying demands prioritization approach and have added a third echelon (regional repair center) in the model capabilities. We completed analyses of the DRIVE model quarterly algorithm, a DRIVE-UMMIPS (uniform materiel movement and issue priority system) comparison and DRIVE-Critical Item Program Comparison. Our FY93 research efforts will again be split between DRIVE model enhancement and policy analysis activities. Both will coincide with JLSC activities. Significant model enhancements are planned for non-flying items and items indentured below shop replaceable unit (SRU) level. Policy analysis will support improved DRIVE Production System operation (engine items and indenture data) and DRIVE's distribution capability usage (DRIVE-D028 Study and analysis of Air Logistics Center distribution applications). (Analyst: Bob McCormick, XPAA, DSN 787-6920)

Logistics Assessment Models (LAMs) Validation and Training: Our roles in this study are to provide an independent validation of the LAMs and develop a training program for system program directors to use in Weapon System Program Assessment Reviews (WSPARs). Our efforts in 1992 focused on developing a LAMs study proposal/validation plan and on receiving in-depth training on the mathematical foundations upon which the models are based. The LAMs consist of the Weapon System Logistics Assessment Model (WSLAM), Tactical Systems LAM (TLAM), and Airlift LAM (ALAM). The LAMs provide weapon system program directors and major command logistics programmers with an analytical tool that relates weapon systems support funding to capability. (Analysts: Capt Richard Moore, Fred Rexroad, XPAA, DSN 787-6920)

Two Level Maintenance Analysis Support. We have been very involved with the CORONET DEUCE F-16 two level maintenance tests. We took the lead in integrating the various analysis efforts for CORONET DEUCE I which ran for eight months starting 1 July 1991. As part of this effort, we quantified the impacts on the MAJCOM reparable support division (RSD) budget by doing comparisons of two level and three level maintenance using both actual base data and Dyna-METRIC 6 generated data. For CORONET DEUCE II, which started in July 1992, we concentrated on helping to implement a PC version of the DRIVE model which could be run daily. The two-week DRIVE used during CORONET DEUCE I was not timely enough for a two level operation. Using figures from the Logistics Management Institute (LMI) cost benefits analysis for all candidate two level avionics parts (not just the F-16 parts), we did an analysis showing how sensitive any possible two level cost savings are to the percentage of base maintenance personnel retained and the decrease in the depot unit repair cost. We have also been doing excursions using the aircraft availability model (AAM) to develop two level candidate parts lists to help the MAJCOMs more accurately identify the parts to move to two level maintenance. (Analyst: Barbara Wieland, XPAA, DSN 787-6920)

Engine Pipeline Study: The objective of this study is to establish a system to manage engine pipelines and to develop procedures to establish and maintain engine pipeline factors. Our goals of this project are to provide credible pipeline factors for improved requirements, establish realistic peacetime pipeline standards based on historical data as a benchmark for comparison with future pipeline times, and provide a structured process to update and manage pipeline factors. We developed a prototype database and new engine pipeline reports containing new factors which we presented to the 1992 Propulsion Managers Conference. We sent the programs and documentation used to develop the factors and reports to OC-ALC/TILC to be loaded into the Comprehensive Engine Management System (CEMS). XPS is working with the CEMS programmers to answer questions and resolve any problems encountered while these programs are being loaded onto the production system. (Analysts: Tom Stafford, Harold Hixson, Phil Persensky, XPSCA, DSN 787-7408)

Readiness Based Initial Requirements Determination (RBIRD): Readiness based sparing (RBS) is a way of determining the spares needed to achieve an aircraft availability goal at least cost. In recent years, the Air Force has applied RBS to reduce spares

requirements for both peacetime (replenishment) and wartime. This study focused on the application of RBS to the computation of initial recoverable spare parts. We developed a provisioning database/spares calculation system based on the logic in the AAM and tested it using C-17 data. Documentation and PC-based software are available. (Analysts: Michael Niklas, Karen Klinger, XPSCA, DSN 787-7408).

Weapon System Management Information System (WSMIS): Our primary roles in support of WSMIS are system design, validation of contractor-developed products, and trouble-shooting. Our efforts last year focused mainly on designing new reports and an automated validation process for the sustainability assessment module (SAM). The new reports will provide a command metric (based on war spares), and the automated validation process helps ensure that erroneous capability assessments will not degrade the credibility of the assessment/problem part identification process. Reductions in the number of people assigned to perform assessments necessitated the increased amount of automation. (Analyst: Michael Niklas, XPSA, DSN 787-6920)

Requirements Interface Process Improvement Team (RIPIT): We participate on a cross-functional team tasked to look at accuracy and completeness of the data in our peacetime requirements computations. The Recoverable Consumption Item Requirements System (D041) relies heavily upon data passed to it from the Worldwide Stock Balance and Consumption Report Consolidation System (D104). D041 uses, in part, the asset and usage data it receives from this system to compute buy and repair requirements. D104 receives its data through a chain of interfaces which starts with the maintenance systems for usage data and the D035K system for asset data, and passes through such systems as the Stock Control and Distribution (SC&D) Item Manager Wholesale Requisition Process subsystem (D035A) and the SC&D Recoverable Assembly Management Process subsystem (D035C). We analyze the system interfaces and work with representatives from other directorates to identify and correct the problems in the requirements process. We also work with ALC representatives on problems they have found in the field. As problems are identified, corrective action is taken immediately and validation of the fix is done by our team to ensure the process is working properly. (Analysts: Bill Morgan, Jennifer Musick, XPSA, DSN 787-6920)

Joint Logistics Systems Center (JLSC) Support. As the main math modeling group for AFMC, XPS has been asked by the JLSC to take part in a joint DOD effort to devise common requirements models to be used by all the DOD components. The JLSC "math models group" has already made recommendations concerning the computation of economic order quantities (EOQ) and safety levels for Air Force consumable items and all Army, Navy, Marines, and Defense Logistics Agency (DLA) items. They have recommended models for computing terminations, retention, and demand forecasting. Since the Air Force is the only component currently using multi-echelon, readiness-based sparing techniques in a production mode, XPS has been a major player in working on a readiness-based requirements model for DOD use. Current research involves modifying the AAM to incorporate the desires and unique procedures of the other DOD components. (Analysts: Fred Rexroad, Bill Morgan, XPSA, DSN 787-6920)

Aircraft Availability Model (AAM) Excursions. XPS has an emulator that mimics AFMC's production version of the aircraft availability model. It is particularly useful for running "what if" scenarios to see the implications of various alternatives to the current resupply system on aircraft readiness and sustainability and support system costs. In May 1992, we were able to provide the Commander, AFMC, with the implications of some proposed spares funding cuts. We determined that, even with many adaptations such as more extensive lateral resupply, stripping part of the fleet for cannibalizations, and systematically reducing resupply pipeline times, one of the proposed funding cuts would ground the fleet unless the flying hour program were cut in half. This information was presented by the Commander to the Senate Armed Services Committee. Currently, we are using the emulator to determine which items would require an additional buy and/or a reliability improvement under two levels of maintenance with two different resupply time excursions. (Analysts: Fred Rexroad, Bill Morgan, XPSA, DSN 787-6920)

The senior staff consists of:

Mr Victor J. Presutti, Jr., Director (XPS), DSN: 787-3201

Mr Curtis E. Neumann, Analytic Applications Division (XPSA), DSN: 787-6920

Mr John L. Madden, Concept Development Division (XPSC), DSN: 787-7408

Miss Mary E. Oaks, Study Program Manager (XPS), DSN: 787-4406

USAF LOGISTICS POLICY INSIGHT

Assessing Supportability

SAF/AQ Policy Memorandum 92M-009, Assessing Supportability, 18 April 1992, states that supportability criteria must be established to help manage and test the operational suitability of a program. The objective is to assure that support actions are on-track as a program exits from one acquisition phase to the next. Supportability exit criteria are based on readiness and sustainability requirements specified by the user in the Operational Requirements Document/Requirements Correlation Matrix (ORD/RCM) and as key parameters in the Acquisition Program Baseline (APB). Critical tasks will be identified to meet the exit criteria to achieve the supportability requirements of the user. The critical tasks will be captured in the System Maturity Matrix (SMM). Program Executive Officers/Designated Acquisition Commanders (PEOs/DACs) will provide copies of the supportability exit criteria and critical support tasks reflected in the SMM as they prepare for a milestone/program review. (Maj Don Williams, SAF/AQKL, DSN 225-7984)

AF Pollution Prevention Program Policy Directive

The Air Force Pollution Prevention Program Policy Directive (AFPD 19-4) was published in October 1992. This policy outlines the Air Force goal to prevent future pollution by reducing hazardous materials use and release of pollutants into the environment to as near zero as feasible. Reasons for emphasizing pollution prevention are skyrocketing disposal costs, liability for cleanup, and disappearing solid waste landfills. The program is based on several objectives: eliminating the purchase of ozone depleting chemicals; reducing municipal solid waste disposal; and reducing use of 17 priority chemicals identified by the Environmental Protection Agency (EPA) as being widely used toxics that can be easily replaced. To track progress towards meeting the goal, the Air Force established an objective to reduce the amount of hazardous waste disposed of by 50%, by 1997, from a 1982 baseline. We are also monitoring our purchases of ozone depleting chemicals and the 17 most polluting toxics, as well as the disposal of municipal solid waste. Since approximately 90% of our hazardous material is for the maintenance of weapon systems, we are focusing efforts on the total life cycle of weapon systems: from concept phase through ultimate disposal. Wherever possible, we will stop using a hazardous material or provide a non-hazardous substitute. (Maj Tom Morehouse, AF/CEVV, DSN 297-0276)

Material Management of Bulk Petroleum

On 1 October 1992, material management of bulk petroleum within the Department of Defense fell under the Defense Logistics Agency's (DLA) Defense Fuel Supply Center (DFSC). Contract operations and maintenance (O&M) projects, including those funded by environmental accounts, starting in FY93, and Military Construction (MILCON) programming and execution, starting with the FY96 MILCON, will become DFSC responsibilities. They will approve and fund all related O&M projects and, through DLA, approve, support, and manage the MILCON for all systems holding their product. Services will continue to manage the FY94 and FY95 MILCON through programming and execution. At the direction of the Office of the Assistant Secretary of Defense (OASD), the FY93 O&M program will be funded by DFSC and reimbursed by the Services. Funds spent for FY93 set the budgeted amount for future years. (Rita J. Maldonado, AF/CEOP, DSN 225-8944)

Relocatable Facilities

The Air Force Audit Agency (AFAA) recently completed an audit on the acquisition and administration of interim office and storage facilities (relocatables). The audit was conducted at five MAJCOMs (Air Force Logistics Command, Air Force Systems Command, Air Training Command, Military Airlift Command, and Tactical Air Command). The audit concluded that Air Force managers did not adequately review relocatable facilities before approving the acquisition of these facilities or properly control the cost after acquisition. Specifically, the audit found that Civil Engineering and using organizations at some bases were:

a. Acquiring relocatable facilities without completing economic or lease versus purchase analyses.

b. Approving unnecessary enhancements to relocatable buildings—buildings must be austere and not have a look of permanence to them.

c. Using interim facilities for more than three years without obtaining approval from SAF/MII as required by Air Force directives. (Maj Robert Kwiatkowski, AF/CEPP, DSN 227-2434)

Cost Saving Alternatives for Computer Replacements

Lieutenant Colonel Werner W. F. Braun, USAF

The military has never been more cost conscious than today; and, as our own budgets continue to shrink, it will become even more so. The theory that we should be running our areas of responsibility similar to that of civilian counterparts dictates that we carefully balance our operation and maintenance (O&M) dollars and temper technological advances with reality and politically sound decisions. As military managers, we cannot show profits, depreciate assets, or buy investments that cannot be fully substantiated. We must, therefore, become experts in our fields, find the best way of doing our job, and then purchase equipment to allow this to happen. Remember, the motto "Let's get the biggest bang for the buck" is more important now than it has ever been.

On the computer front, we are faced with continuous, fast-paced software and hardware advances—advances that need to be incorporated into the workplace when and if possible. This will not only allow us to stay abreast with technology and continue to grow with industry, but it will also continue to ensure a military equal to none. However, given our monetary constraints, we no longer have the latitude of upgrading computer systems without having to seriously consider the possible impacts to mission, manpower, and other essential services. We must manage smarter, be more knowledgeable of alternatives, and make decisions that previously may not have been the "politically" right thing to do.

My job as the Deputy Commander for Resource Management, 3636 Combat Crew Training Wing at Fairchild AFB, Washington, placed me in just such a situation. Looking at numerous computer alternatives, I had to decide as to when, how fast, and to what extent our wing would embrace this wonderful new technology. Yes, you heard right! This was in large part to be an initial capability; here we were in the 1990s and just starting to embrace the computer age.

We were to my knowledge the last Air Force organization to "become of age." It was high time to replace the trusty old typewriters. Lack of ample capital forced us into installing used systems—systems obtained from organizations that were already upgrading their equipment. We therefore inherited "Convergent Technology (CT)" hardware, a host-user type system with a primary server and network stations attached. This system with its technology is about ten years old, but working well. (Sounds like I am talking about an old supervisor of mine.) As we were installing initial assets, our efforts were halted. Lack of funds for the command-managed and paid-for maintenance contract dictated that no additional systems/components could be installed and used. (Even so, there were additional systems available.) The requested (and finally approved) answer was to remove our wing from the maintenance contract entirely and allow us to continue our upgrade. We now were "different" from remaining Air Training Command (ATC) bases and therefore "on our own." (Using excess units as spares, we filled the maintenance void through a "remove-and-replace" concept.)

Contrary to popular belief, we were not only doing well without a maintenance contract, but we were prospering without suffering from mission-impacting downtimes. This was primarily due to two reasons: a very capable, dedicated, and multitalented computer technician; and our search and locating abilities that ensured available assets for both expansion and spares support. We located and received systems from the US Coast Guard, Military Airlift Command (MAC), Air Force Institute of Technology (AFIT), and our own command. (All was, of course, free of charge.)

To date, we are almost totally computer automated; that is to say, a computer on every desk. Yes, it is true that the system is still an old system; but I must say that it is meeting 95% of our needs. After all, when you really look at your "need," it usually can be categorized into a word processing need. Yes, it would be nice to install and use more modern, faster, and user-friendly software; but, again, *the system is meeting the need.* Having stated that, we are in fact planning an upgrade based on command requirements, not on nice-to-have wishes, dreams, or personal preferences that many times drive new purchases. Here is where the ALTERNATIVE portion of this article enters the picture.

I mentioned that our systems are castoffs from organizations that **needed** new systems. Most are going to very costly alternatives—total replacements. But, I had to ask myself: What are the real requirements? I, too, realize that it would be nice to change to a new IBM, WANG, or other "state-of-the-art" component, but what is actually **needed**? Our command-driven requirements turned out to be POSIX and GOSIP compliance; and a distant third, nice-to-have need, was DOS compatibility. Bottom line: we were looking at a **SOFTWARE** need, not a **HARDWARE** need.

Given our structure of approximately 300 work stations, we did some quick research and came up with the following costs/comparisons:

	MSDOS	**UNIX**	**CTOS(our system)**
PRICE:	$1200K	$650K	$110K
MAINTENANCE:	VERY HIGH	HIGH	LOW
MANPOWER:	7.6	6.6	3.5
USER TRANSITION:	HARD	VERY HARD	VERY GOOD
FUNCTIONALITY:	GOOD	POOR	GOOD
FLEXIBILITY:	FAIR	FAIR	GOOD
STANDARDS:	FAIR	GOOD	GOOD
MSDOS:	BEST	POOR	GOOD

Putting facts into perspective, with costs for upgrading existing systems being as low as 10% of alternatives, one would have to have some extremely compelling reasons **not** to upgrade the old hardware.

Easier said than done, especially when your command is upgrading in a totally different direction. I, therefore, expected some tense discussions and possible disapproval when I had a stroke of good luck. Our HQ/SC (Colonel Chaplin, a true officer and gentleman, who listened to reason and helped to cut through the ever present bulk of red tape) visited us and offered his assistance. We took this opportunity and briefed our present success as well as future desires. He not only applauded our

efforts and endorsed our plans, but is now directing our maintenance philosophy at other bases. Depending on adoption, we expect monetary savings in reduced maintenance contracts alone to exceed $1 million per year. Our savings from upgrading existing hardware versus new stand-alone computers range from $550K to $1M. An additional benefit from using the same hardware will be user friendliness—not having to learn a new system. This often creates extreme anxieties with the work force and is often a much overlooked benefit.

As of today, we are moving ahead with our alternatives and expect to be upgraded long before our command counterparts, primarily because of the comparatively small cost which can be justified and approved much easier than multimillion dollar upgrades. Therefore, if you find yourself in a similar situation, I highly recommend that you research your alternatives, ensure you know the real requirements, and then fight to get command approval and funding.

Colonel Braun wrote this article while DCRM at Fairchild AFB, Washington. He is presently Commander, CFC HQ/C-4, Korea.